POWER

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THE $50 PRIZE

for the best article on

The Operation of a Steam Turbine

has been awarded to

PAUL HOFFMAN

of Easton, Pa.

The Judges:

H. G. STOTT,
Sup't Motive Power, Interborough Rapid Transit Ry.

J. D. ANDREW,
Sup't Power Stations, Boston Elevated Ry. Co.

OLAFE OLESON
Chief Engineer Commonwealth Edison Co., Chicago

have unanimously decided that of the 46 articles submitted his was the best.

They also agree that that submitted by F. R. Brosius, of Columbus, Ohio, is second in merit.

Mr. Hoffman's article will appear in full in an early issue. The others will be used more or less extensively, or in so far as they contain different ideas and suggestions, and all the authors, including the prize winner, will be compensated in proportion to the use made of their material.

Old English Power Plants

By John S. Leese

Some very old engines and boilers which have passed the century mark are described. A few are still in operation, using coal which is a byproduct of the clay which they hoist.

While a description of what is undoubtedly the oldest operating steam plant in the world cannot fail to interest power-plant men, it will surprise many present-day engineers to learn that its engines and boilers are still performing their everyday service satisfactorily and reliably.

The writer visited this plant of the Madeley Wood Co., at Iron Bridge, Shropshire, England. The bridge from which the town takes its name is itself of considerable historical interest to engineers. It spans the River Severn, and was constructed in 1779 by Abraham Darby, of Coalbrookdale Works. It is the first iron bridge of record and has a single arch of 120-ft. span. Describing the bridge, Robert Stephenson said: "If we consider that the manipulation of cast iron was then in its infancy, a bridge of such dimensions was doubtless a bold as well as an original undertaking, and the efficiency of its details is worthy of the boldness of its conception."

Fig. 1 shows the plant of the Madeley Wood Co. This spot is known as the Wharf Pit. The engine is used solely for pumping, and three boilers, two of the haystack and one of the egg-ended type, supply it with steam. It was impossible to obtain a picture of the engine itself, owing to the darkness and lack of space inside the engine house. This engine has an open-top steam cylinder, 26 in. in diameter, and has an 8-ft. stroke. The beam is of cast iron and has a working length of 20 ft., the "main gudgeon" being 10 ft. from each end.

At the water end of the engine are two working barrels, each of 9¾-in. bore, working from a depth of 300 ft., the lift accomplished by each barrel being 150 ft. The two haystack boilers are 16x14 ft. and the egg-ended boiler is 6 ft. in diameter by 28 ft. long. This installation works at a steam pressure of from 8 to 10 lb. The boilers are constructed of ⅜-in. cast-iron plates with single-riveted lap seams; the pitch of the rivets is 1¾ in. center to center. The boilers have 4-in. bore, mushroom-type safety valves. The coal consumption of the pumping set is 1½ tons of slack coal per day, working continuously, which is not high. The equipment is approximately 115 years old.

Beyond the company's office are three blast furnaces, the lining of one of which is 27 years old and is still in good condition. Beyond the furnaces are the engines shown in Figs. 2 and 3. The engine in Fig. 2 was installed in 1779; its working life terminated in 1889. This engine was used for clay-pit winding work and has an oak crank web. The man with the shovel was the fireman at this installation during the latter years of its useful life.

Fig. 3 is a view of the Blests Hill Clay Pit winding engine. It is a "compound" engine having open-top "hot" and "cold" cylinders of 35 and 24 in. bore respectively. The "cold" cylinder is shown at the right of the picture. The beam is 14 ft. long from the end to the connecting-rod journal. The flywheel is 13 ft. in diameter, and the crankshaft is geared to a second-motion shaft with a speed reduction of 4 to 1. The winding sheaves are mounted on the second-motion shaft. The chains, clearly shown, are built of wrought-iron links with wooden packing or distance pieces. They sustain loads of between 18 and 20 cwt., and the lift now is 300 ft.

A cast-iron haystack boiler, seen in the background, is 10x12 ft. and has ⅜-in. plates and single-riveted lap seams. Between 8 and 10 lb. is the pressure carried. The safety valve is of the mushroom type and has a 4-in. bore. This engine consumes 16 cwt. of slack coal per day and was installed 105 years ago.

Further on, is the Shaws Pit winding installation, Fig. 4, which includes the winding gear, engine house, boilers and smokestack. This engine lifts 18 to 25 cwt. 660 ft. The engine has a single 36-in. cylinder with a 4-ft. stroke, and the working length of the beam is 14 ft. 5 in. The 15-ft. flywheel is driven with a gear reduction of 4 to 1 from the crankshaft to the second-motion shaft. Steam is supplied at 4 to 6 lb. pressure by a 10x12-ft. haystack boiler and a 5x20-ft. egg-ended boiler, both equipped with mushroom-type safety valves. The coal consumption of this engine is unknown, the coal used being that raised with the clay. This installation dates back about a century. The driver, shown in the photograph, is 72 years old and succeeded his father as the driver of this engine.

In Fig. 5, a view through the engine-room door of the Shaws Pit engine house, may be seen the connecting-rod, crank web, pressure gage, pump rod and valve-gear.

Fig. 6 was taken from the platform shown in Fig. 5 and gives a clearer view of the valve-gear. The valve rod and roller tappet are plainly visible, as are the controlling lever and the seat where the engine driver sits in full view of the pit mouth.

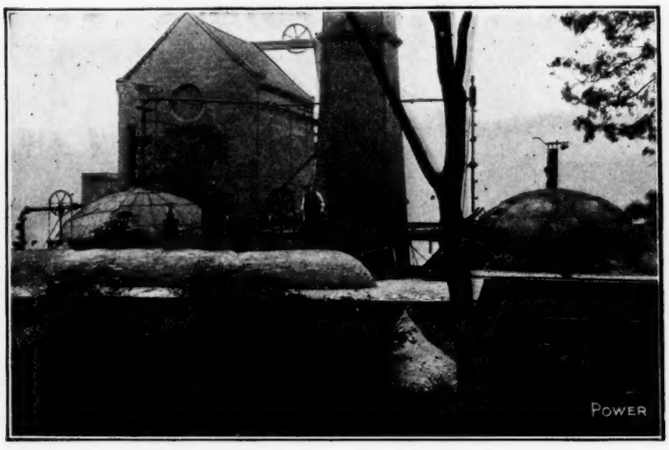

FIG. 1. PLANT OF THE MADELEY WOOD CO.

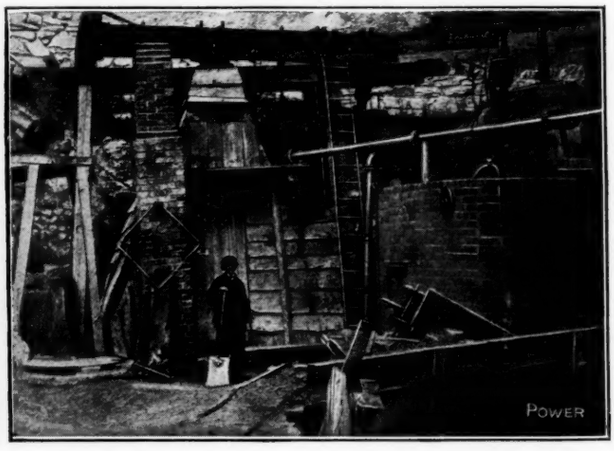

FIG. 2. AN INSTALLATION OF 1779

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Both the Blests Hill Pit and the Shaws Pit engines have overwinding alarm bells in addition to the dial indicators inside the houses. The alarm bell, seen in Fig. 4 through one of the spaces between the flywheel arms, is operated by a knocker arm which is rotated and moved axially by the scond-motion shaft so as to act at a determined height and depth. Reaching diagonally upward from the base of the alarm-bell pedestal is the rod operating the winding indicator inside the engine house. In Fig. 3 the bell can be seen through the arm of the second-motion shaft pinion, also the indicator rod which passes through the wood wall of the engine house.

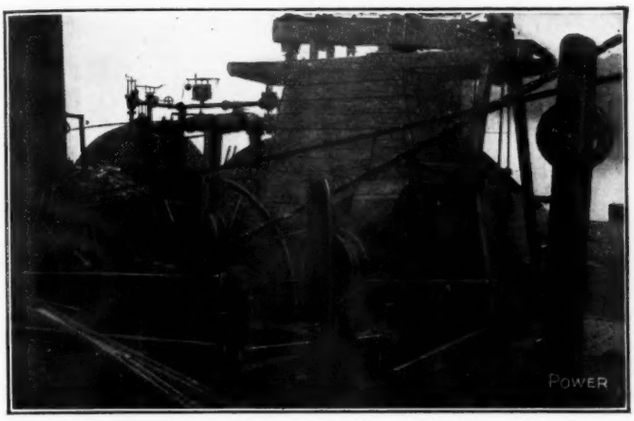


FIG. 3. AN ANCIENT WINDING ENGINE

FIG. 4. SHAWSPIT WINDING INSTALLATION

All these engines are of Newcomen type, water being injected into the cylinder to condense the steam below the piston at the end of each upstroke. The pistons are packed with rope and have a water-seal maintained 2 in. deep upon their upper surfaces. The engines run at from 8 to 16 strokes per minute and operate very smoothly. The beams, shown in Figs. 2, 3 and 4, and the supporting gantries are of oak.

Who built the engines is not known, but the Wharf Pit engine is of the genuine Newcomen type. The Blests Hill and Shaws Pit engines are locally known as "Adams" Newcomen engines.

The Newcomen engine in the South Kensington Museum is supposed to be fairly old, but the Madeley Wood Co.'s installations are said to be older still; moreover, they are still running.

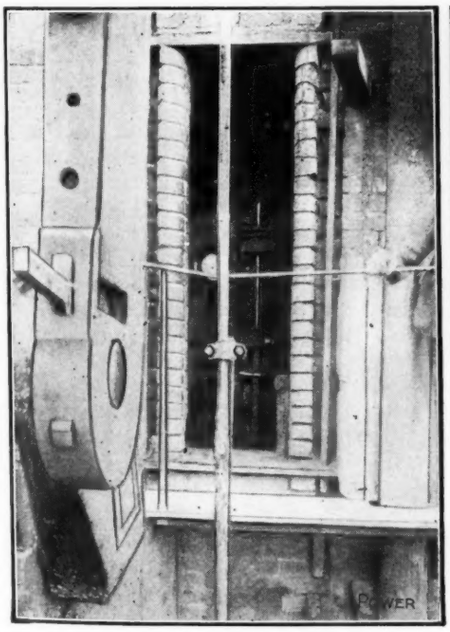


FIG. 5. SHOWING CONNECTING ROD OF THE SHAWSPIT ENGINE

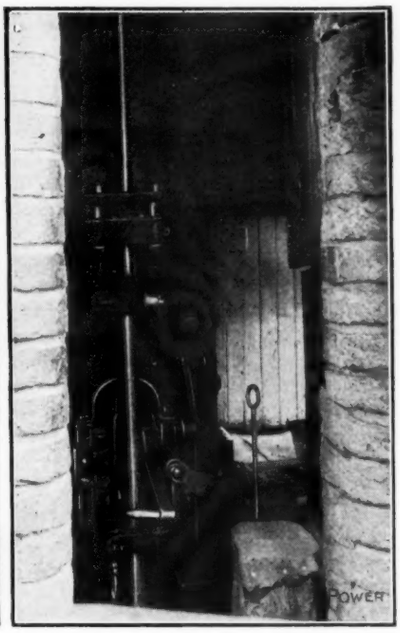


FIG. 6. SHOWING CONTROLLING LEVER OF THE SHAWSPIT ENGINE

The writer is indebted to the chief engineer and his staff for the foregoing details of this article.

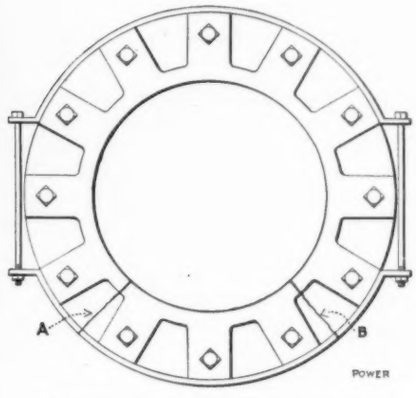
Nearly 32,000 tons of graphite is imported by Germany annually. The average price of American graphite is $135.66 a ton at Hamburg.

Reinforced Broken Flange

By W. H. Wakeman

One of the flanges on a 12-in. pipe line began to leak steam. An investigation showed that a section had broken out at *A* and *B*, but was held in place by three flange bolts. The pressure on this line is usually about 4 lb.; it is never more than 8 lb. After the break was discovered the pressure was reduced to 2 lb.

The external diameter of the flange is 19 in. Two $\frac{5}{8}$x1$\frac{1}{2}$-in. iron band clamps were made to fit around it as shown, so made that when put in place the ends were 6 in. apart. Holes $\frac{1}{16}$ in. in diameter were bored though these projecting ends, and when $\frac{5}{8}$x9-in. bolts were inserted in them they cleared the flange about $\frac{1}{4}$ in.



HOW THE BROKEN FLANGE WAS REINFORCED

When the clamps were put in place a piece of sheet packing was put between the lower clamp and the broken piece. After the packing was thoroughly heated the nuts were again tightened and once again the next morning.

Nothing more was done to the flange, and it is now perfectly tight. The clamps cost less than $3, making a very cheap repair job and yet one that is entirely satisfactory.

Duchesne's Experiments on Superheat

V. Dwelshauvers-Dery*

For saturated steam the author finds a substantial agreement between the temperatures of the steam tables, those indicated by mercurial thermometers and those shown by the very sensitive thermo-couple which he uses. For superheated steam, however, there is a wide difference, increasing with the degree of superheat, the mercurial thermometers reading in some cases 70 or 80 degrees below the thermo-couple. In a mass of superheated steam there may be strata of different temperatures and even moisture. This calls into question all the determinations upon superheat in which mercurial thermometers have been used. The variation of the specific heat of superheated steam is determined by the author and it is shown that as the pressure increases all its properties become independent of the pressure and vary only as a function of the temperature.

*Professor emeritus, University of Liége.

The observant experimenter frequently finds out things in the course of an investigation for which he had no thought of looking. The work of the clever investigator, Armand Duchesne, instructor at the University of Liége, Belgium, affords a new example. He started out to study the variation of the temperature of the steam and the metal of the containing cylinder of a steam engine during the period of compression.

As during this period the steam is generally superheated, and a poor conductor, while the temperature varies at each instant, it was necessary that he should have a thermometer, so to speak, without calorific capacity. This necessity resulted in his invention of what he calls a "hyperthermometer," an electric thermocouple of which the platinum and silver wires have a diameter of $^1/_{100}$ of a millimeter (about 0.0004 of an inch) and present numerous junctions disseminated throughout the space of which one wishes to determine the temperature in such a way as to give the average temperature instantaneously or nearly so.

It is not all to create a thermometer. It was necessary still to calibrate it with all the exactitude possible; the more so as the author wished also to verify the law

$$\frac{pv}{T} = constant$$

for the superheated vapor of water, by operating with high compression in the cylinder of a steam engine. This would be the second time that an apparatus of the size of a steam engine should serve to determine physical laws, with as much as, if not more, precision than the diminutive apparatus of the ordinary laboratory. The first time was when Hirn attempted to determine the mechanical equivalent of heat by means of the Logelbach engine, with a capacity of 150 hp.

It was in the calibration of his hyperthermometer that Monsieur Duchesne first encountered the unexpected. Comparison with a mercury thermometer in the same current of steam was the only available method. Steam was made to flow slowly through a large pipe furnished with a thermometer close to the boiler, called the auxiliary thermometer t_a, passing through the metal of the pipe by means of a stuffing-box and plunged in the current of steam. On the same pipe was a second mercury thermometer t_v placed in a thermometer cup screwed into the pipe and filled with oil. Finally came the hyperthermometer, or thermocouple of silver and platinum, arranged as shown in Fig. 1.

Saturated steam was used, the only medium which can furnish a given temperature constant and uniform at all its points. The pressure was shown by a large mercury column, and the temperature by the steam tables which was that of the hot junctions. The wires of platinum and of silver communicated respectively with the large wires of the same metal, which issued by insulated stuffing-boxes from the steam space in which the instrument was used. They were connected to conductors which led to the galvanometer, and submerged in vessels containing melting ice. All of the apparatus was protected so far as possible against loss of heat by radiation.

Monsieur Duchesne gives in his treatise the results of six groups of experiments, of which the average temperatures, as given by the mercurial thermometer, t_v, were about 115, 129, 139, 150, 156 and 162 deg. C., differing from the tabular values of the temperatures of the saturated steam in which the thermometer was immersed by only a fraction of a degree.

When one operates with saturated steam the thermometer t_v at the end of a certain time indicates, therefore, a temperature of saturation close to the temperature marked by the auxiliary thermometer t_a, or determined by means of the pressure and the steam tables, and the hyperthermometer is in accord or nearly so. But when one operates with superheated steam this is no longer true. The thermometer t_v no longer accords with the auxiliary thermometer and the greater the superheat, the greater the lack of agreement.

Here is the explanation of this fact: Saturated steam gives up its heat freely, and consequently the heat of the mass of saturated steam passes in quantity across the thermometer cup and the oil to the thermometer t_v, and the internal surface of the oil cup is not cooled. But if the steam which surrounds the oil cup is superheated, it is only the film of steam adjacent to the exterior surfaces of the oil cup which participates in this exchange of heat, on account of the low conductivity of superheated steam. The thermometer t_v will, therefore, indicate a temperature inferior to that of the auxiliary thermometer.

Applying the same reasoning to the auxiliary thermometer, which is plunged directly in the steam, one is justified in concluding that it will not give exactly the temperature of the environment in which it is plunged if surrounded by superheated steam, and that it will be necessary, in order to determine this temperature exactly, to have a thermometer without calorific capacity.

The hyperthermometer of Duchesne responds practically to this condition, if it is properly calibrated. The calibration of the thermometer has been effected experimentally with the greatest care, the details of which are carefully set forth in the treatise.

It is necessary now to compare the indications of the simple mercury thermometer with those of the hyperthermometer of Duchesne. The experiments were made under varying pressures as follows: 17,084, 27,024, 36,228, 48,759, 56,762, 66,930, kilograms per square meter (from about 25 to about 95 lb. per square inch) and under each pressure with degrees of superheat varying from zero (saturation) to 173, 185, 117 and 98 deg. C. The differences between the indications of the hyperthermometer and the mercury thermometer increased in each case the more the superheat was augmented, and amount to 85, 79, 54, 55, 46 and 43 deg. for the foregoing pressures. The diagrams giving these differences are curious to study and show that they are governed by very definite laws.

Repeating these experiments with the apparatus more perfectly protected against heat radiation, there was obtained a notable attenuation of these differences as follows:

17,000	27,000	48,000	59,000	68,000	kg./m.²
8.1	80.6	49	39	33	deg.

These results were certainly unexpected.

Monsieur Duchesne, wishing to push to the utmost his tests on this important point, which may call into question all the experiments which have been made on superheated steam with mercury thermometers, plunged the mercury thermometer into the center of the mass of superheated vapor, passing it through the wall of the containing pipe by means of a stuffing-box. With this arrangement the differences diminish as follows:

18,000	28,700	38,600	49,200	59,500	70,100
7.6	6.1	3.5	3.3	3.1	2.0

These differences are thus reduced to the order of possible errors in the evaluation of the temperatures by the hyperthermometer, but they are always of the same sign, which justifies the belief that it is the latter instrument which gives the true temperature.

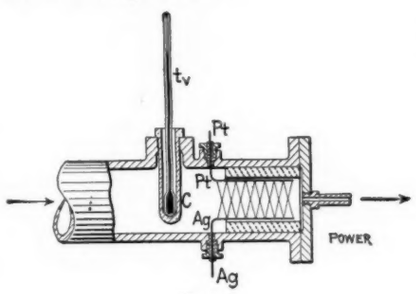


FIG. 1

The explanation given by Monsieur Duchesne of the difference between the temperatures indicated by the hyperthermometer and the thermometer t_v involves the hypothesis that in the body of the same mass of superheated steam are to be found contiguous layers or strata of steam of very different temperatures. Hirn had already remarked this. Monsieur Duchesne has demonstrated it experimentally; he has shown even that there may exist strata of saturated steam.

In brief, then, one first point is established, that with superheated steam all observations of temperature may be false if they are not made with a thermometer practically without mass.

In possession of an apparatus adapted to determine exactly the temperature of superheated steam, Monsieur Duchesne had the ambition to investigate experimentally the law of the compressibility of the superheated vapor of water; that is to say, the law which connects the pressure p, the absolute temperature T and the volume v' of a kilogram of that substance. Many authors have given formulas, a résumé of which may be found in the remarkable work, "La Vapeur d'Eau Surchauffée," by Monsieur Marchis, professor at the Sorbonne, of Paris. Other works are those of Zeuner, of Tumlirz, of Weyrauch and of Callendar, but none is directly based on experiment.

In the laboratory founded by the writer at the University of Liége, numerous diagrams had been taken by the indicator on the steam engine, operating with a high degree of compression. The greatest precaution had been taken to obtain a precision as absolute as possible in the measurement of the pressures and the volumes of steam during compression. The temperature at each instant had not been determined. But there is one quantity of the highest importance which experiment does not give directly; that is, the weight of steam in action during the compression, and consequently that which had been inclosed in the cylinder at the moment of the closure of the exhaust valve.

One could calculate the weight of pure steam inclosed at that moment, since the diagram gave its volume and its pressure, from which could be deduced the weight per cubic meter by means of the steam tables. But might not this steam be accompanied by a weight of condensed water deposited as dew on the metallic walls of the cylinder?

Hirn had assumed that this water did not exist, that the walls were dry and the steam saturated, without, however, furnishing any positive proof; but he had added that the question would not find its definite solution except in the study of very long compression. In fact, to George Duchesne, the older brother of Armand, is due the credit of having decided this point. By an intelligent analysis of the diagrams of compression he has shown that the hypothesis of humidity in the cylinder at the commencement of compression is untenable, because at that moment *the temperature of the metal is considerably higher than that of the steam;* that not only must the steam be dry and saturated, but that it is probably superheated; that without taking into account the slight superheating, the weight of vapor present can be regarded as equal to the product of the volume occupied in cubic meters by the weight of a cubic meter of saturated steam, as given in the tables at the pressure measured on the indicator diagram.

The diagram of the indicator, therefore, shows directly at each point of the compression curve the pressure p and the volume occupied by the steam. Indirectly, it permits the calculation of the weight of steam m acting during the compression, and consequently the volume v' per kilogram for each point. There remained only the temperature T to determine to establish the function

$$\frac{pv'}{T} = C$$

Monsieur Duchesne traced a diagram of this from the indications of his hyperthermometer, and he worked with unusual compression, up to nine-tenths of the stroke. From this collection of data he drew his conclusion with as much positiveness and genius as science. Such is the work resumed in his thesis, which has received the favorable recognition of the eminent professors of the Sorbonne at Paris, Messieurs Appel, Koenigs and Marchis.

The method adopted by Monsieur Duchesne for calculating the weight of fluid operating during the compression is particularly remarkable and worthy of consideration. He traces the curve of experimental temperatures during the compression. Upon it he superposes the curve of temperatures of saturation from the commencement of the compression. These curves at first are identical. Then they separate, the experimental curve mounting more rapidly than the other. It is at the point of separation of these two curves that the steam ceases to be saturated, and becomes superheated.

This point may, therefore, be taken as that of the coördinates of the curve which will furnish the element for the

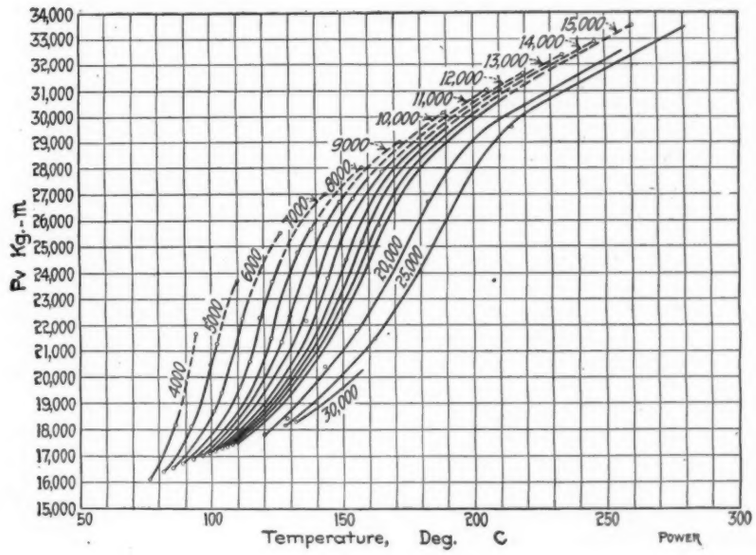


FIG. 2

calculation of the weight m of the steam operating during the compression; that is, the volume occupied in cubic meters and the weight of a cubic meter of saturated steam at the indicated pressure. If

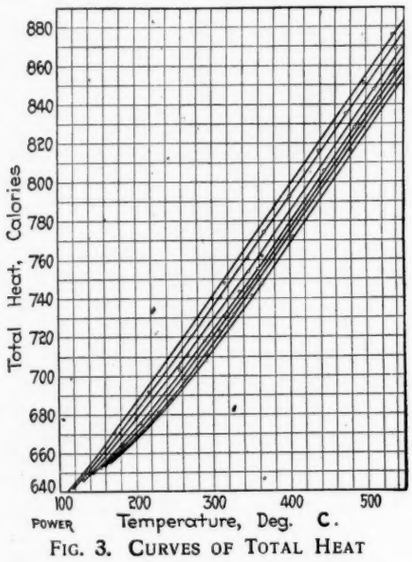


FIG. 3. CURVES OF TOTAL HEAT

this method does not give an absolutely certain result, it may in any case be said that it assures an approximation as great as may be hoped for in practice.

One may now trace, according to the table of experimental results, diagrams in which pv' and p are plotted as functions of the temperature. These tables and diagrams are included in the memoirs of Monsieur Armand Duchesne on pages 40 to 48. Here is reproduced only the curve deduced from the preceding, and giving for a constant pressure indicated on the curve itself as abscissas the temperatures t, and as ordinates the values of pv'. These curves illustrate, therefore, the equation

$$pv' = f(t)$$

each one for one value of p, Fig. 2.

An examination of this group of curves will show that each of them finishes by taking a rectilinear course, according with the increase of temperature and commencing with a certain value of t. And further, if the rectilinear portion of either of these lines is continued toward the left in a straight line, it will intersect the axis of temperatures at the point which marks the absolute zero; that is to say, at

$$p = -273 \text{ deg. C.}$$

which leads Monsieur Duchesne to the two following conclusions:

FIRST PROPOSITION: *For a given pressure, the superheated vapor of water obeys the law of Gay-Lussac beyond a certain limit of temperature; that is to say, that at constant pressure the product* pv' *is proportional to the absolute temperature* T. *Below this limit the law of compressibility is represented by a curve, which has a point of inflection, and of which the form corresponds fairly well to an equation of the third degree.*

SECOND PROPOSITION: *If the superheated vapor of water is at a temperature sufficiently above that of its point of saturation, its properties approach those of a perfect gas, and the greater its pressure the more this is so.*

Monsieur Duchesne has not given his results without having submitted them to thorough verification, both mathematical and experimental, which, however, would be too long to develop here. Among the properties of superheated steam he wished to determine with his habitual exactitude the total heat λ' of a kilogram of steam saturated at t and superheated to t'. He made superheated steam to flow for an hour at a temperature t' into a surface condenser, where a continuous current of water condensed and cooled it to a temperature $t'f$, taking from it the quantity of heat necessary to elevate its own temperature from ti to tf.

The tables give the heats of a kilogram of water at various temperatures, and notably $q'f$ for $t'f$, qi for ti, qf for tf. If during the hour there has flown from the boiler to the condenser a weight M_a of steam, which has been superheated from t to t', the quantity of heat carried to the condenser is $M_a\lambda'$. This heat has raised the temperature from ti to $t''f$, of the weight M_c of circulating water in the condenser which carries off, therefore, $M_c(q''f - qi)$. On the other hand, at the outlet of the condenser the condensate, in weight M_a, has preserved a temperature $t'f$ and a heat value $M_a q'f$. One has, therefore,

$$M_a\lambda' = M_c(q''f - qi) + M_a q'f$$

+ the losses of all sorts. Whence

$$\lambda' = \frac{M_c}{M_a}(q''f - qi) + q'f + \frac{losses}{M_a}$$

In order to appreciate the method by which Monsieur Duchesne determined the losses, it will be necessary to read the memoir itself. The smaller quantity, M_a, the water coming from the condensation of the steam, was collected in a gaged receptacle provided with a thermometer. The gage gave the volume and, knowing the temperature, the weight per cubic meter could be easily determined.

The weight of the circulating water was determined by causing it to pass over a weir, accurately calibrated in advance. At short and equal intervals of time the height of the water level above the sill of the weir was observed, and the average was taken. The table belonging to the weir gives the volume of water which has passed over it per second or per minute, or per hour. A thermometer placed near the weir gives the average temperature of this water. From the

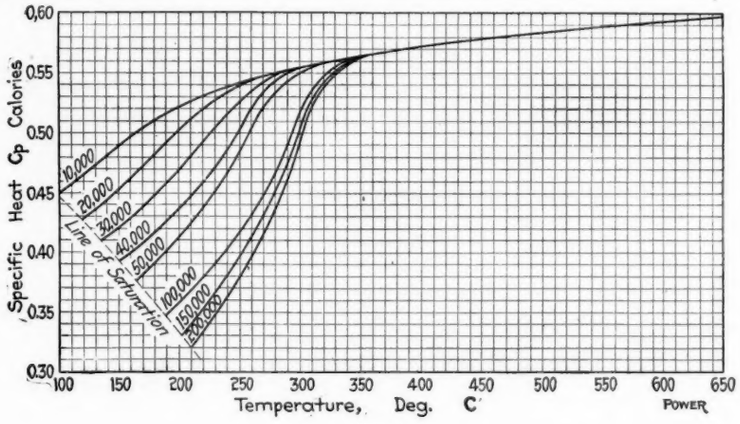


FIG. 4

tables can be deduced the weight per cubic meter, and consequently the weight of the volume past M_2. No experiment was commenced until uniform conditions had been thoroughly established, so that there should be no difference between the initial and final states.

The above described method was applied as follows: Several tests were made maintaining the pressure constant and varying the temperature of superheat, which gives for the various pressures the variations of the total heat of the superheated steam as a function of the temperature. As it was impossible to maintain the same pressure rigorously throughout all the tests of the same series the pressure has been calculated, assuming that whole series was made at the average pressure.

At the limit, the properties of slightly superheated steam must accord with those of saturated steam. For each curve there is obtained, therefore, one more point in calculating the total heat of vaporization, and the temperatures of saturation corresponding to the pressures. The mean pressures chosen were about 10,000 kilograms per square meter apart.

Monsieur Duchesne has devoted in all 65 experiments to this research of the total heat of superheated steam. The figures of Regnault relative to saturated steam at seven mean pressures furnished seven points, making 72 in all. Monsieur Duchesne has discarded eight of these, the results of which fell off of the line more than 0.8 per cent. There remained, therefore, 64 points.

In this way has been formed the group

of curves, Fig. 3, the tangent of which makes with the axis of temperatures an angle of which the tangent is equal to the specific heat at constant pressure C_p. It will be seen that as the pressure increases the curves of λ' approach each other more and more, so that for a sufficient pressure they will become identical; that is to say, the specific heat at constant pressure would become independent of the pressure whatever was the temperature.

This fact is perfectly explained by the diagram, Fig. 4, obtained in part by extrapolation, the ordinates of which are the values of C_p at different pressure for the temperatures indicated by the abscissas between 10,000 and 200,000 kg. per square meter of pressure. It will be seen that at about 360 deg. the specific heat C_p becomes nearly independent of the pressure and depends only upon the temperature with which it augments regularly.

The last chapter of this remarkable study of Monsieur Duchesne, in which he resumes his conclusions, calls attention to the divergencies which exist between his results and those relative to the values of C_p found experimentally by Messrs. Knoblauch and Jakob. These divergencies are explained by the fact that these gentlemen used in their experiments for the measurement of the temperature of superheated steam the mercury thermometer in the usual cup of oil, which is massive and slow in responding to changes of temperature. It follows that there is a considerable error in their estimation of the difference of the temperatures of superheat between which they have evaluated the mean specific heat at constant pressure C_p. This difference increases as the steam approaches the point of saturation. It tends to disappear toward 360 deg. C.

Two difficulties are to be found in the measurement of the temperature of superheated steam passing even slowly through a space, as of a pipe. First, the temperature is not uniform throughout the mass as it would be with saturated steam, on account of the slow conductibility of the superheated fluid. An instrument is necessary which gives the average temperature, as the piston of an indicator gives the average pressure, and instantaneously as does the indicator piston. In this connection it is safe to say that the mercury thermometer can give only the local temperature, and that tardily, especially if it is in a cup of oil. The hyperthermometer of Duchesne, with its numerous junctions disseminated through a large space and its excessively small mass sensible to heat, meets these conditions as far as is practically possible.

The importance of the effect of these two factors will be appreciated when it is remembered that in some of the experiments the difference between the mercury thermometer in its oil bath and those of the more responsive and sensitive thermocouple amounted to more than 80 deg. C.

Immense Power Plant Project

Significant of the progress of constructive operations in the inauguration of the largest electrification project since the Niagara power plants, is the recent execution of a contract by the Lehigh Navigation Electric Co., Philadelphia, Penn., with the General Electric Co. The contract calls for three 10,000-kv.-a., 11,000-volt, three-phase, 25-cycle, horizontal turbo-generating units with two 300-kw. turbo-exciters and one 300-kw. motor-generator exciter to be installed in the new main generating station at Hauto, Penn.

An initial expenditure of $3,000,000 is contemplated and an eventual investment of $10,000,000, with an assured supply capacity of 20,000 kw. from the first installation of the three 10,000-kw. turbo-generators and a gradual enlargement to 100,000 kw. capacity. This is said to be the beginning of the most important step ever taken in the United States toward the economic use of coal and generation of electrical power on a large scale using fuel.

Hauto is about 10 miles west of Mauch Chunk, at the mouth of a railroad tunnel leading from the Lehigh Coal & Navigation Co.'s main body of anthracite coal at Lansford. From here the distribution of current for heat, light and power by high-voltage transmission lines reaching out through all eastern Pennsylvania and New Jersey, will reach 2,500,000 people.

By transforming the coal into electric energy at the mines and transmitting it direct to consumers, handling, loading, hauling and dumping will be eliminated. At present the company has an annual waste of about 500,000 tons of coal particles and dust. As this culm is unmarketable, it will be burned in the company's boilers, thereby effecting another large saving.

The main generating plant was located at Hauto because of an abundant water supply, the reservoir being increased to 1,000,000,000 gal. capacity, with an area of about 400 acres by the construction of a higher dam. The water-supply needs of the ultimate plant will be some 300,000,000 gal. daily, most of which will be carried back into the reservoirs after condensation. To run the plant at the contemplated maximum capacity of 100,000 kw., approximately 1,000,000 tons of coal will be needed yearly, which would require 20,000 cars to carry it to market.

Among the first power consumers will be the slate and cement industries in Lehigh and Northampton Counties, all from 20 to 40 miles from the Hauto plant. Substations will probably be established at once at Coplay and Pen Argyl for stepping down and distributing the current to users. Within a radius of 50 to 75 miles from the main station are some 20 large cement mills. The transmission lines will be strung largely along the Lehigh Navigation Canal and on the right-of-way of the Lehigh & New England R.R. which the company controls.

A complete power census of the district reached by the distribution system of the first section of the Hauto plant shows that over 100,000 hp. is now used. The Lehigh Navigation Electric Co. has made up a schedule of prices, running from 8 mills to about 2½c. per kilowatt-hour, according to the power contracted for and the steady continuance of consumption. Current can be delivered cheaper than the industries can produce it by steam power.

As under Pennsylvania laws the right of an electric-power company operating with steam to distribute energy is confined to a single township, charters have been obtained in Lehigh, Schuylkill, Carbon, Northampton, Bucks and Montgomery Counties for about 60 electric companies. The first companies organized are the Hazard Co., Hanover; Oakdale Co., Salisbury; South Whitehall Co., South Whitehall; Equitable Co., Whitehall; North Whitehall Co., North Whitehall; Diamond Co., Washington; Upper Macungie Co., Upper Macungie, and Upper Milford Co., Upper Milford. All subsidiary companies will be consolidated under the management of the Lehigh Navigation Electric Co.

It is expected that the first installation at the Hauto plant will be in operation before the end of the year. As the plant capacity is gradually increased, energy will be carried to Allentown and Easton, Penn., Trenton, N. J., and finally into Philadelphia.

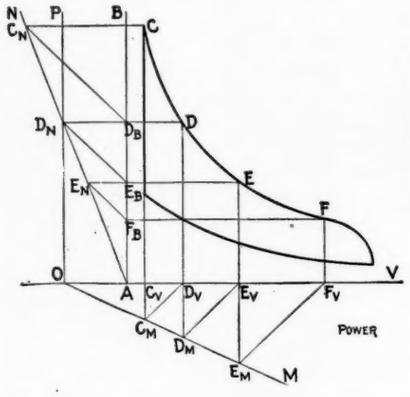
A New Analysis of Indicator Cards

In the article under the above title in the issue of June 18, page 859, an error was made in the drawing for Fig. 3 by not copying correctly the figures on the horizontal scale of volumes. On the right side of the diagram the figure 2 should be where 3 is, 3 where 4 is, 4 where 5 is and 5 should be at the end of the horizontal line. The curve is plotted to the correct scale.

The Modern Engineer is a little monthly magazine published by the Modern Science Club, of Brooklyn, and will supersede its year book. Editor Johnson says in its first issue that "the *Monthly* will be purely practical and written for engineers by engineers." POWER wishes it a long and useful life.

Determining Clearance from the Indicator Diagram

In his paper describing a new method of analysis for indicator diagrams, presented to the American Society of Mechanical Engineers at its recent spring meeting, J. Paul Clayton described the application of this method to the determination of the clearance. For the normal case the expansion and compression lines of the indicator diagram will become straight lines when plotted upon logarithmically ruled paper, but, in order that this may follow, the absolute zeros of pressures and of volume, that is, the axes of the curves, must be accurately determined. If the percentage of clearance and thus the position of the clearance line upon the indicator diagram are not known, different values for the clearance may be assumed and the diagram plotted upon the logarithmic paper with the assumed values. If the value is assumed too low the plotted curve will not become a straight line but will lean toward the axis of zero volume, while if too large a clearance is assumed the line will lean in the other direction. By trial with different assumptions for the



clearance, until a straight line is obtained, the actual clearance may be found when the absolute zero of pressure is known, or if the clearance is known accurately the method may be worked in the other direction to definitely determine the zero line of pressure or the barometric reading at the time that the indicator diagram was taken.

This method was illustrated and described in POWER, June 18, page 862.

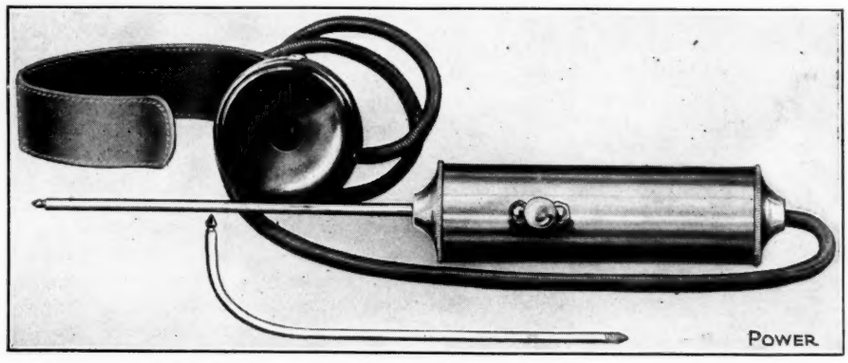
In discussing this paper, Prof. F. E. Cardullo, of the New Hampshire College, presented the method described in the accompanying diagram as being more elegant, more accurate and more simple than the method proposed in the paper. The proof of this method will be found on pages 33 to 35 of Prof. Cardullo's "Practical Thermo-dynamics."

In the figure, *CF* is the expansion line of a gas-engine diagram and *OV* the axis of zero absolute pressure. At any point, as at *A*, on this axis erect the perpendicular *AB* and draw *AN*, making any convenient angle to *AB*. Draw CC_n and draw C_nD_b making an angle of 45 deg. with *AB*. Through D_b draw D_nD and draw D_nE_b at 45 deg. Similarly, draw E_nE, E_nF_b and F_bF. From *F* drop a perpendicular to *OV* and draw F_vE_m, making an angle of 45 deg. with *OV*. From *E* drop a perpendicular which will intersect F_vE_m at E_m. Draw E_vD_m, dropping a perpendicular from *D* to determine D_m. Draw D_vC_m and drop a perpendicular from *C* to determine C_m. If the expansion line *CF* fulfills the equation $PV^n = C$, C_m, D_m and E_m will lie on the same straight line and that line will intersect *OV* at the point of zero volume, or the location of the line bounding the clearance.

Detectorphone

This is an instrument for detecting sound, whether water in pipes or noises of any kind in running machinery, which cannot be heard otherwise. It is a "mechanical stethoscope" and has been designed to locate trouble by applying it to a machine.

The device consists of two parts, a detector and a receiver. The pin of the detector is placed on any part of the machine suspected of derangement and any unnatural sound is transmitted to the receiver, which is held to the ear. This instrument is made by the Boston Talking Machine Co., 41 West St., Boston, Mass.



THE DETECTORPHONE, A MECHANICAL STETHOSCOPE

Circulator for Scotch Marine Boilers

A fault of the Scotch marine boiler is the lack of free circulation of the water, to assist which various circulating devices have been invented.

A device brought out in 1907 under foreign patents is being manufactured in this country by the Ross Schofield Co., 39 Cortlandt St., New York City.

Fig. 1 is a working model of a Scotch marine boiler used for demonstrating at the company's office. The barrel of the boiler is glass through which the circulation of the water is observed. The water currents indicate the path of circulation.

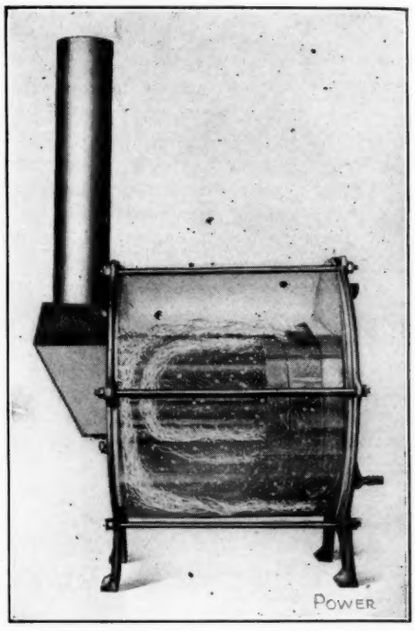


FIG. 1. DEMONSTRATING BOILER

The circulating system consists of a steel plate, supported on the short stays, completely inclosing the water space back of the combustion chamber except at the top and between the furnaces at the bottom; steel plates, supported by the short stays, not from the tubes as shown, placed in front of the combustion chambers and each side of each bank of tubes and back and front hoods. A side view of the combustion chamber and tubes, showing the application of the circulator, is shown in Fig. 2, and a front view of the device in Fig. 3. The circulator is installed without interfering with the boiler and produces a rapid circulation over all parts, increases the capacity of the boiler, lengthens its life, and improves the working conditions in every respect.

The arrangement of the plates provides for two spaces which operate in parallel, their superimposed curved hoods promoting longitudinal and elliptical circulation of the water by utilizing the natural force of the steam bubbles. These

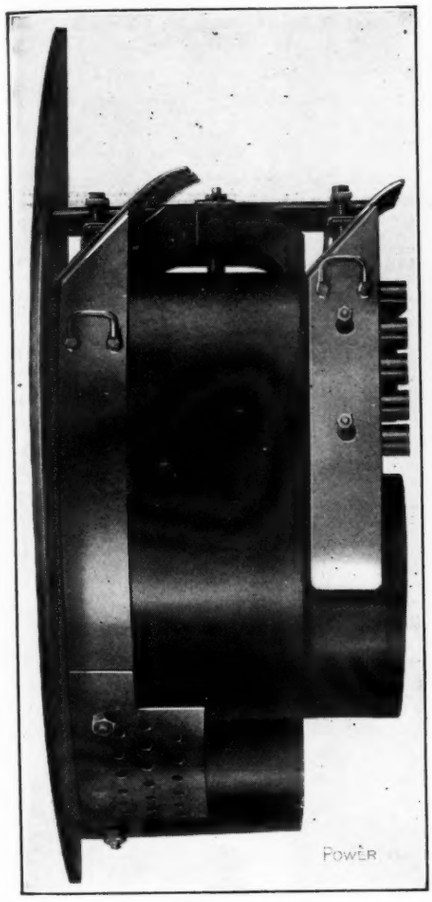


FIG. 2. SIDE VIEW OF THE CIRCULATOR

bubbles, on escaping from the centers of violent ebullition, pass up through the guiding compartments and issue under the curved hoods which deflect the ascending streams of water horizontally and prevent priming. The effect is the promotion of a flow that will continuously draw the water from the lower and colder part

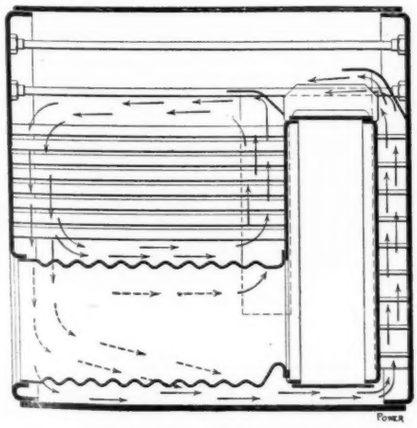


FIG. 4. SECTIONAL VIEW OF SCOTCH BOILER

of the boiler, up between the guiding plates and propel it longitudinally to the front. These conditions are quickly established, are constant, effective circulation is secured and regular and rapid steaming maintained. The sectional view, Fig. 4, indicates the position of the hoods and the path of circulation.

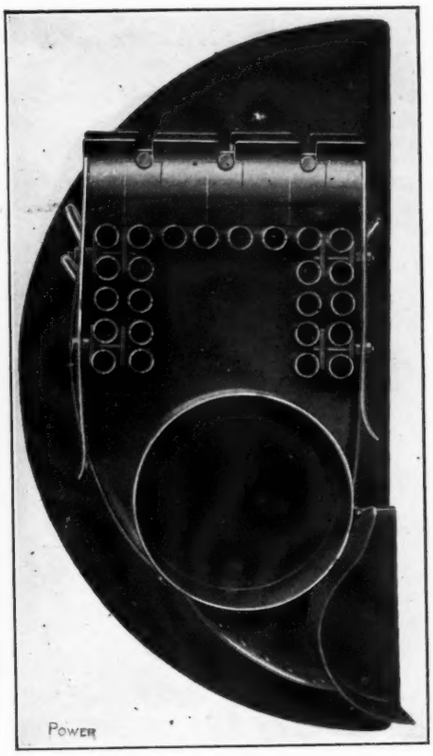


FIG. 3. FRONT VIEW OF CIRCULATOR FURNACE AND TUBES

Electric Heater Prevents Freezing

Electric heaters are used to prevent the water freezing in a large roof tank which supplies the fire-sprinkler system of a New York City loft building. When the system was put in experiments were made with electric heating, and it was found that heaters set in the 18-in. air chamber in the top of the tank, attached to the under side of the air-tight cover, gave the best results. Accordingly, four 1200-watt heaters were installed, with thermostatic control to keep the temperature in the tank from falling below 34 deg. F. Last winter the installation worked with perfect satisfaction, switching the current on and off automatically, and the tank was kept entirely free from ice.

Purchase of Coal on an Ash Basis

The principal impurities in coal are nitrogen, water and ash, all of which may be present in independently varying quantities. From this it would appear that any system of evaluating coal which considers the variation of only one of its three impurities must lead to erroneous conclusions, and while such assumption is correct in general, it is nevertheless true that the method of estimating coal values by ash content alone has, within certain limitations, decided advantages over the calorimeter method.

This is because coal from any particular vein is reasonably constant in its nitrogen and moisture content, however widely its ash may vary; and, moreover, different samples of coal from the same vein vary in commercial value in an inverse but much greater ratio than their variation in ash. It has been found in one series of tests reported in the *Journal of the Western Society of Engineers*, September, 1906, that coal containing 40 per cent. of ash will not generate high-pressure steam when burned in a boiler furnace. Its value is, therefore, nil, yet a calorimeter test would indicate that such a sample of coal has a value equal to 60 per cent. of that which a sample entirely free from ash would have. From this it is apparent that a formula which evaluates coal in inverse proportion to its ash content will give erroneous results.

Assuming that coal containing 40 per cent. of ash has no value as fuel, and assuming the rate of decrease of value is constant as the amount of ash increases, the value of a coal for varying amounts of ash would be represented by the formula:

$$Value = 100 \text{ per cent.} - (2\tfrac{1}{2} \times \text{per cent. ash})$$

But, as the ratio of fuel values to ash content is not a straight line but a curve, decreasing slowly at first and falling off rapidly for ash quantities greater than 30 per cent., a formula to represent the entire range would be quite an involved expression; but as coal containing more than 30 per cent. is rarely used, and as the curve for 5 to 30 per cent. ash is nearly a straight line, it can with a fair degree of accuracy be represented within the range mentioned by the formula:

$$Value = 100 \text{ per cent.} - (1\tfrac{1}{2} \times \text{per cent. ash})$$

which is a formula easy to remember and easy to apply and is much more accurate than the formula:

$$Value = 100 \text{ per cent.} - \text{per cent. ash}$$

In the excellent paper by L. P. Crecelius, entitled "The Purchase of Bituminous Coal under B.t.u. Specifications," which appeared in the report of the Committee on Power Generation, which was presented at the 1911 convention of the American Electric Railway Engineering Association, the author says:

> The presence of an excessive amount of ash in any coal manifests itself in the nature of a reduction of capacity, because of its occupying a relatively large amount of effective grate area with inert matter. It is also a source of additional expense in the matter of cost of removal and extra wear and tear on ash-handling apparatus. It should, therefore, be restricted to a certain limited amount, no premium being allowed for a minimum. Penalties for amounts in excess of the allowable limit should be provided, and these preferably should be-

come excessive after a certain value. The reason for this is principally that the amount of ash is, in a measure, the key to the nature of the coal, and the principal purpose of any coal specification should be to provide a steady and uniform supply of fuel, previously determined upon as best suited to existing plant conditions and to limit all other grades of coal.

This clearly indicates that the author realizes that penalties in direct proportion to the amount of ash would be inadequate to protect the consumer, and that deductions from a price fixed for a standard quality of coal should be in a greater ratio than any increase in amount of ash.—From report of Prime Movers Committee, N. E. L. A.

Chart for Calculating Boiler Tests

By F. O. Pahmeyer*

By use of the chart, the horsepower, actual evaporation per pound of fuel, equivalent evaporation and efficiency may be determined direct from the data of a boiler test, without going into laborious calculations. Examples are given illustrating the use of the chart.

*Engineer with Heine Safety Boiler Co.

The accompanying chart has been constructed to facilitate working up results from a boiler test, and the closeness with which results can be determined will be within the limits of the error of the observations making up the test records. Examples of the several processes of which determinations are made are as follows:

Capacity

Knowing the average steam pressure and the average feed-water temperature, the factor of evaporation can be ascertained from a table or by calculation. The only other item that must be known is the amount of water evaporated per hour.

From the point on the lower scale, representing the amount of water, follow upward the slightly inclined line to its intersection with the horizontal line representing the factor of evaporation found on the left-hand scale. Follow vertically through this point of intersection to the top scale, the reading of which will be the required capacity in boiler horsepower. One horsepower is defined as the evaporation of 34½ lb. of water from and at 212 deg. F. per hour.

By following down instead of up from the point of intersection, the pounds of water from and at 212 deg. per hour may be read off on the bottom line.

Example—Assume that 10,250 lb. of water per hour have actually been evaporated, that the average temperature of the feed water is 110 deg., and that the average steam pressure by gage is 140 lb. per square inch. The factor of evaporation for this temperature and pressure is 1.15. The point of intersection, as just described, carried to the top scale, reads practically 341 hp. This point of intersection, carried down to the bottom scale, reads practically 11,800 lb., which is the equivalent evaporation of water per hour from and at 212 deg. F.

Actual Evaporation per Pound of Fuel

From the point on the lower scale repsenting the amount of water, follow vertically to the intersection with the horizontal line representing the amount of coal. This intersection will fall on one of, or more likely between two of, the inclined lines representing the evaporation per pound of fuel. If between the lines, the reading may be interpolated.

Example—Assume that 10,250 lb. of water have been actually evaporated and 1580 lb. of coal have been fired; it is immaterial whether this is for one or more hours. The point of intersection, as previously found, falls practically on the line representing 6.5, which is the actual evaporation of water per pound of coal as fired.

Equivalent Evaporation from and at 212 Deg. per Pound of Fuel

The actual amount of water evaporated, the total amount of fuel burned, the average feed-water temperature, and the average gage pressure of the steam for any period must be known. Determine the factor of evaporation and find the equivalent evaporation from and at 212 deg. as described under "capacity." Follow vertically or down from this point of intersection to the horizontal line through the amount of fuel consumed, which point of intersection will fall on one of, or between two of, the much inclined lines, which represent the water evaporated per pound of fuel.

Example—Assume that 10,250 lb. of water have actually been evaporated and that 1580 lb. of coal have been burned in the same period of time. Let the temperature of the feed water be 110 deg., and the steam pressure 140 lb. per square inch; these conditions corresponding to a factor of evaporation of 1.15. The equivalent evaporation from and at 212 deg., as found under "capacity," gives 11,800 lb., although it is not necessary to follow down to the bottom line. The intersection, with the amount of coal burned, falls between the lines representing 7.25 and 7.5, which would be estimated as 7.45, the amount of water evaporated from and at 212 deg. per pound of coal as fired. This same method may be followed to determine the evaporation per pound of dry coal if the moisture is determined and deducted from the total weight of coal, and as well for the evaporation per pound of combustible if the moisture and ash are deducted from the weight of coal as fired, and the remainder used as the amount of fuel burned.

Efficiency

From the point on the bottom scale representing B.t.u. per pound of fuel, follow vertically to the much inclined line representing the equivalent evaporation from and at 212 deg. per pound of fuel. From this point of intersection follow horizontally to the efficiency scale at the right-hand side.

Example—Assume that the coal burned has a heat value of 12,100 B.t.u. per pound and that the equivalent evaporation from and at 212 deg. is 7.45 lb. of water, in accordance with the preceding examples. The point of intersection will be on a line, which will follow horizontally so as to give a reading of 60 % on the efficiency scale.

Remarks

In the foregoing examples it is assumed that there is no moisture in the steam. If it is desired to take any possible entrainment into consideration that quantity must be determined and the total amount of water evaporated decreased by the amount of moisture so found, or correction can be made by reducing the factor of evaporation by the same percentage. For example, if the total amount of water evaporated is 10,250 lb. and the moisture in the steam is 2 per cent., the true amount of water evaporated would be

$$10{,}250 \times 0.98 = 10{,}045 \text{ lb.}$$

which quantity should be used in place of 10,250 in the determinations. Or the factor of evaporation could be reduced by 2 per cent., making it 1.127, which should be used instead of 1.15. The final result would be the same in either case.

Where the quantities of water and fuel determined are beyond the limits of the diagram, results may be determined by dividing these amounts by two, three or any other factor that may be necessary, then proceed as before. To determine the capacity the result found must be multiplied by the same factor that was used individing. The results for evap-

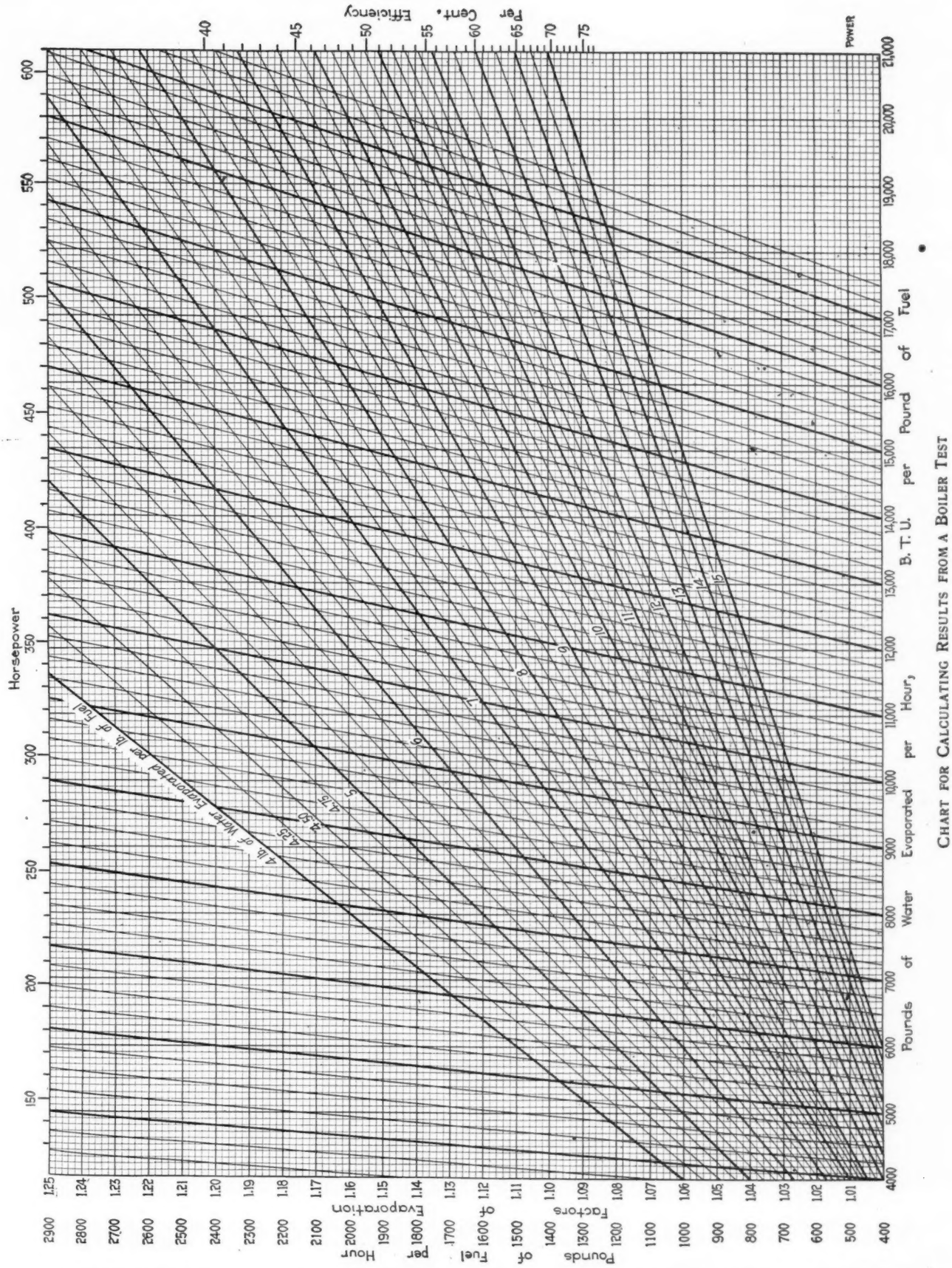


CHART FOR CALCULATING RESULTS FROM A BOILER TEST

oration per pound of fuel must not be again multiplied, presuming, of course, that the fuel is reduced in the same proportion as the water.

The chart will give results sufficiently close for all but very refined determinations, and will be found of great assistance in quickly arriving at results during a test, and for the use of those who have not the time or detailed knowledge to perform the various calculations involved.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Setting Motor Brushes

By J. S. Kinney

In reassembling direct-current motors after repairs have been made, the brush-holder arm is often moved, accidently or otherwise, so that the correct position has to be found before the motor will give good commutation. The correct position of the rocker-arm is marked on some but not on all motors. There are several ways to set motor brushes, but generally they are set, either mechanically by the eye, or electrically by the "kick method."

Interpole motor brushes must be very accurately set to obtain satisfactory operation. If the armature is parallel wound

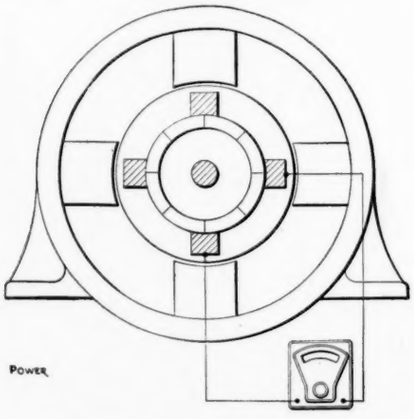


Fig. 1. Voltmeter Connection for Determinating Neutral Position by "Kick Method"

and the winding is sufficiently open to enable the armature conductors to be readily traced, the brushes should be set so that a coil, the two halves of which are directly under the centers of two consecutive interpoles, will have its ends connected to two adjacent commutator bars which are centrally located under the brush that is being adjusted. This armature coil, together with its commutator bars, can be marked and the remaining brushes set by rotating the armature until the marked coil comes under the next interpole and the last one of the first pair, and so on until all the brushes have been set. If there are several turns per coil, the middle turn should be used.

With wave-wound machines, the spread of the coils, or the winding pitch, as it is called, is not the same as the angular pitch of the poles. With this style of winding, which is quite common on small machines and necessary on multipolar machines having but two sets of brushes, it is best to have one side of the coil slightly back of the middle of its interpole, and the other side of the coil a little ahead of its interpole. The commutator bars to which this coil is connected should be under adjacent brushes of the same polarity, with one brush of the opposite polarity between. Usually the number of commutator bars will not be an exact multiple of the number of

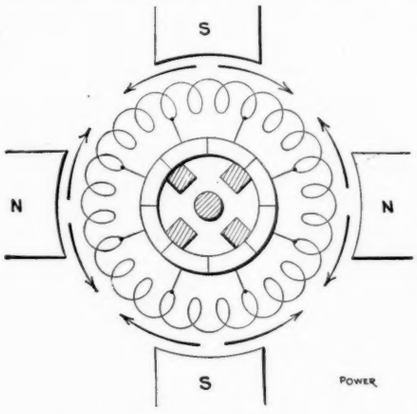


Fig. 2. Ring Wound Armature

poles, and the final position of the rocker-arm will have to be an average of neutrals found for each set of brushes.

The "kick method" is more often used to determine the no-load neutral position of the brushes. A low-reading voltmeter, of about 5 volts full-scale deflection, is connected to two adjacent brushes, as in Fig. 1. The field is excited with normal field current on small machines, and about 25 per cent. of normal field on large machines, and is "flashed" by alternately making and breaking the field circuit. If the brushes are not on neutral, the voltmeter needle will be deflected in one direction when the circuit is closed, and in the opposite direction when it is opened. The kick is greater when the field switch is opened, as the time element is very much less than when the switch is closed. The deflection obtained on opening the circuit should be used in setting the brushes. The rocker-arm is shifted while the field is being flashed, until a position is found in which no deflection is obtained. This should be tried with the meter leads connected to each pair of brushes, and the position of the rocker-arm which gives the best average is the correct setting. With a two-circuit wave-wound armature, a position of no deflection cannot be found because the number of commutator bars is not an exact multiple of the number of poles. In this case, the proper position is that which will give the minimum sum of readings.

Closing and opening the field circuit, with the armature stationary, causes

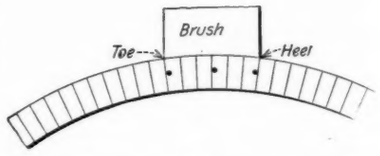


Fig. 3. Showing Where to Hold Voltmeter Leads

equal electromotive forces to be induced in the armature coils under adjacent poles. These forces oppose each other and neutralize at the correct brush position. A ring-wound armature, for example, is shown in Fig. 2. The neutral for this style of winding is half-way between the main poles. The arrows indicate the manner in which the electromotive forces oppose each other, and neutralize at the neutral position of the brushes. In the actual machine of to-day, the neutral is on the center line of the main poles.

An easy and convenient method of checking the neutral is to run the motor under full load, at its highest rated speed, in both directions. These speeds should agree within 2 per cent. Any difference in speeds may be decreased by shifting the brushes slightly in the direction in which the motor runs the faster. In an interpole machine, an armature conductor comes under a main pole and then an interpole of the same polarity, so that in reversing the direction of rotation, the armature and the interpole should be considered as a unit, and the current reversed in both, to maintain the proper relation between the main poles and interpoles.

It is well to see that the interpole is of the proper strength, if it has in any way been changed during the overhauling of the motor. One lead of the 5-volt voltmeter is attached to the brush-holder arm, and the other end is held against the end of the commutator under the brush, at each edge of the brush and in the middle. The dots in Fig. 3 indicate the proper positions for holding the lead. This should be done at each of the rated speeds of the motor, and at several loads. The interpole is of proper strength if

the three voltmeter readings are approximately the same; but if the voltmeter readings increase from the heel to the toe, the interpole is too strong. Where the motor has to carry heavy overloads, a slightly overcompensated field is desirable to take care of the saturation of the interpoles at the overloads. Removing one or two of the sheet-iron shims under the interpole, thereby increasing the bore, will weaken the interpole, or it may be weakened by removing some of the turns. Still another way is to shunt the interpole winding with a strip of german silver. Increasing the number of turns or decreasing the bore by the addition of shims will strengthen the interpole.

Exactly the same procedure is carried out in finding the flash neutral on non-interpole machines. Motors which are to be operated in one direction only are usually given a backward lead of from 1½ to 2 per cent. of the total number of commutator bars. A backward lead of from ¾ to 1 per cent. is given to variable-speed machines. The brushes are left on the flash neutral position on machines designed to operate in both directions, such as elevator and crane motors. Increasing the backward lead increases the speed of the motor, while decreasing the amount of lag slows it down. If a motor fails to come up to its rated speed

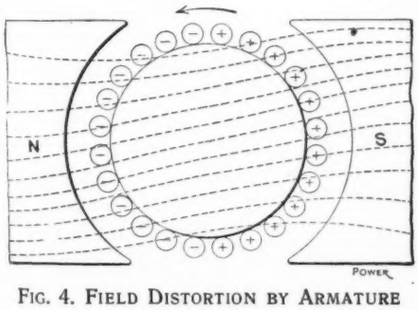


FIG. 4. FIELD DISTORTION BY ARMATURE REACTION

at full load and increasing the backward lead occasions excessive sparking, either the bore of the main poles must be increased by removing shims or the shunt field weakened by introducing external resistance in the field circuit. Often serious sparking is caused by the brushes not fitting, or becoming wedged in the brush-holders.

The distortion of the main field by armature reaction is illustrated in Fig. 4, and is due to the magnetic field produced by the armature acting at right angles to the main field. As the load on a motor increases, the armature current becomes greater, and consequently the armature flux is strengthened since it depends on the ampere turns. This changes the neutral and the brushes must be given more lag. In nearly all motors, the magnetizing force of the field is great as compared with that of the armature, which reduces to a minimum the amount that the neutral shifts.

A slightly greater amount of lag than that required by armature reaction is always given to the brushes to take care of the self-induction of the armature coils. This additional lag brings the coil in which current is to be commutated into a field of opposite polarity just before it comes under the brush, and the self-induction is taken care of and the coil commutated with minimum sparking.

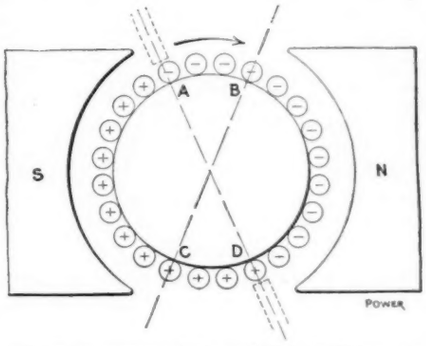


FIG. 5. SHOWING WHY MOTOR SPEEDS UP WITH INCREASE OF BRUSH LAG

The reason a motor speeds up with an increase of brush lag can be seen from Fig. 5. The armature coils included in twice the angle of lag (between *A* and *B*, and *C* and *D*) produce a flux which opposes that of the main field. These turns are called the back-ampere turns of the armature and are partially compensated for when the motor is designed, by increasing the number of ampere turns on the field. As the angle of lag increases, the number of back-ampere turns increases, and the main-field strength is thereby decreased, with a resultant increase in the speed of the motor. Since the speed of the motor is proportional to the counter-electromotive force in the armature (the field flux remaining constant) the effect of the increase of back-ampere turns is augmented by a decrease in the number of armature conductors available to produce the counter-electromotive force. These conductors, which are represented by those between *A* and *D* and *B* and *C*, are decreased as the brush lag is made greater.

Starter for Direct-Current Motors

A direct-current motor-starter, designated as "type S," has recently been placed on the market as by the Westinghouse Electric & Manufacturing Co.

The magnet switch, shown in the front view, Fig. 2, opens and closes the circuit, and its blowout coils prevent injurious arcing. With the interlocking devices and the overload relay, this switch affords low-voltage and overload protection. Opening the double-line switch (in the middle of the panel) disconnects the motor and starter from the line. The multipoint starting switch (at the left) cuts out by steps the starting resistance shown in the rear view, Fig. 1. This switch has an interlocking contact at each end, either one of which must be closed before the magnet switch can operate.

With the starting switch wide open, the operator closes the line switch and then the starting switch, step by step, while he holds its upper interlocking device closed. Owing to the action of the two interlocking devices, he cannot start until all the resistance is in circuit, nor can he leave the motor operating with part of the resistance in circuit. When closed, the starting switch holds the upper interlocking device closed.

An overload, either while starting, or while running, operates the relay, causing the magnet switch to open the circuit. Failure of voltage also opens the magnet switch. After either, the starting switch must be completely opened, placing all the starting resistance in circuit,

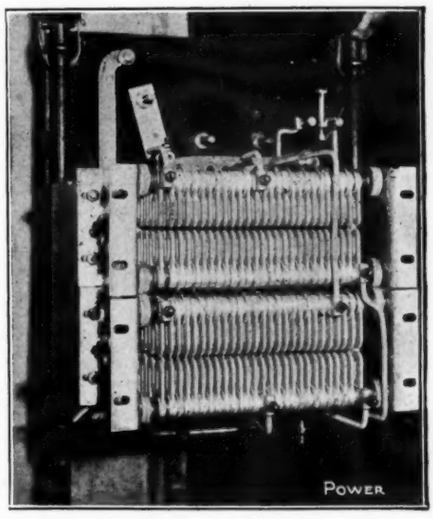


FIG. 1. BACK VIEW OF STARTER

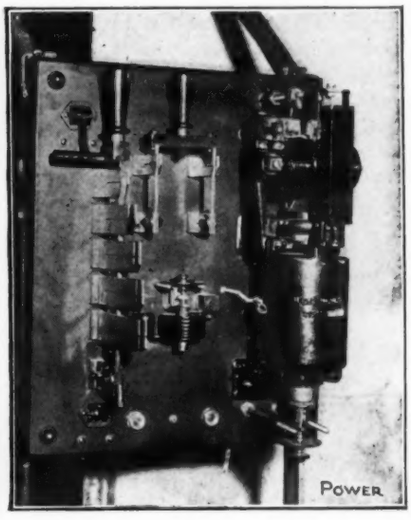


FIG. 2. FRONT VIEW OF STARTER

before the motor can again be started. Merely pulling out the starting switch far enough to release the upper interlocking device stops the motor, the circuit then being opened by the magnet switch dropping.

The starter is built in capacities suitable for 115-volt motors of from 10 to 60 hp., 230-volt motors of from 12½ to 125 hp. and 550-volt motors of from 30 to 250 hp.

CORRESPONDENCE

Motors Will Not Carry the Load

In reply to J. L. Shrode's inquiry, in the June 18 issue, my experience teaches that an unusual drop in speed in an induction motor, if it is not overloaded, is generally a sign of high resistance in the rotor. Thorough soldering at the ends of the bars should remedy the trouble, even when screws are used. From outside appearances, the soldering may seem sufficient, but upon thoroughly sweating in the solder a great difference will be found. This does not mean simply sticking on the solder, but heating the rotor with an iron and torch so that the solder will run freely; before cooling, the joint should be wiped smooth and clean with a cloth or waste.

I have had motors, normally running at 1800 r.p.m., drop to 1200 r.p.m. and be brought back to their full load speed by applying solder as directed. Contrary to Mr. Shrode's experience, I generally find them running very warm when the trouble is due to this cause.

Another source of trouble may be found in the running connections. In starting, the motor is thrown on the line and, after reaching the proper speed, is thrown on the fuses or running side. If a fuse is blown, a wire broken, or there is a poor contact in the starter, this would cause the motor to run single phase and it would not carry much load. This condition may be detected by testing with a lamp, if the voltage is not prohibitive, or a voltmeter and ammeter connected beyond the starter.

An uneven air gap may cause the motor to slow down, and if a heavy load is thrown on, the rotor will strike the laminations and stop; this will blow the fuses. If the motor is in a good location, this may be observed by taking off the belt and looking through the air gap, placing a light on the opposite side, if natural light is not sufficient. Have an assistant start the motor and, when up to speed, shut off the current. If the bearings are very much worn, the rotor will be seen to rise and fall. When having bushings or bearings babbitted, I have them bored out to within 0.005 in. and have never had one fail.

R. LENON.

Keene, N. H.

Regarding Mr. Shrode's trouble with motors not carrying loads, I submit the following suggestions:

It would seem that there is too much resistance at the connection of the rotor bars to the short-circuiting rings, which condition would increase the slip, thereby accounting for the drop in speed at full load. A very little resistance at these points would tend to affect the speed materially. In a 7½-hp. machine, possibly the resistance is introduced by shellac or some kindred material used for insulating the rotor bars, or dirt, the rings not being drawn to a firm, clean electrical connection with the rotor bars.

Regarding the second motor: this is a fairly common occurrence with soldered squirrel-cage windings. The local heating on one end most likely is due to imperfect or loosened soldered connections. The usual remedy is to resolder the bars, clinching them to the rings with a set and hammer, if possible.

C. E. MEAD.

New York City.

Commutator Lubrication

In a recent issue I noticed an inquiry as to the lubrication of generator commutators. We have a 10,000-kw. plant and once had considerable trouble due to "shorts" in the commutators caused by the charring of the mica between the commutator segments.

Then we were using clean engine oil on the commutators. I tried paraffin, but that was not satisfactory. I then prepared a compound of two parts by weight of paraffin, two parts of petroleum and one part of kerosene, mixed together and melted. When cold it forms a thick paste which can be applied to the commutator in a small quantity with a rag. The commutator should then be rubbed off good with a dry cloth to remove any surplus grease. This compound proved highly satisfactory and our commutators are now in excellent condition.

JOHN M. GLENN.

Chicago, Ill.

I have found that the best way to lubricate commutators, keep the brushes from chattering and avoid sparking, is to boil the brushes in a good grade of cylinder oil for about 24 hours once a month.

One of your correspondents recommends rod packing, but this did not work well in my case, on account of the commutator cutting the packing. Our commutator is slotted. Packing might be used on slow-speed machines having the mica cut down.

J. B. LINKEN.

Charlotte, N. C.

The dynamo Mr. Drewry mentions, in the June 4 issue, is certainly exceptional, and must be working under a steady load to give such results. He does not say what it is used for, but I do not think it can be an exciter. We have a very unsteady load, the exciter current varying from 60 to 95 amp. every few minutes. The exciters are controlled by a regulator, and, with the best of care, the commutators have to be turned down at least once a year and sometimes more often.

Mr. Hansa's rod packing is probably all right. If it is lubricated hemp it will pick up the dirt and lubricate a little at the same time, and if a rubber packing, the graphite will smooth up the brushes, thus stopping the cutting and sparking.

We have one exciter that causes considerable trouble. It has been turned down several times and sandpaper has been used to scour it, oiling slightly after scouring. Gasoline has also been tried after sandpapering and has given good results.

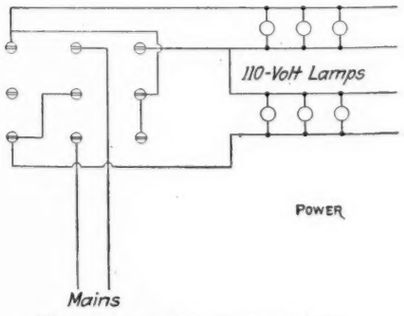
When the brown color of the commutator begins to turn black, it is a sign that it is getting dirty. We then moisten a piece of waste with gasoline and hold it on the commutator for a few seconds; this cleans off all the dirt, and the gasoline that gets on the brushes quickly evaporates before any dirt has a chance to collect. We use a part-graphite brush, as it has been our experience that a carbon brush will harden next to the commutator in a short time.

V. C. WOOD.

Copenhagen, N. Y.

Lighting Circuit for 220 or 110 Volts

The connections shown in POWER of May 21 for operating a lighting circuit on either a 220-volt or a 110-volt supply circuit with 110-volt lamps could be made with any standard triple-pole double-throw knife switch (leaving the middle clip on the left-hand end dead) without



WIRING FOR 220 OR 110 VOLTS

any special attachments, as shown in the accompanying diagram.

Closing the switch to the left connects the two groups in series for operation on 220 volts and closing it to the right puts the two groups in parallel for a 110-volt circuit.

P. JUSTUS.

Cleveland, Ohio.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

American Practice in Rating Internal Combustion Engines* †

By T. C. Ulbricht and C. E. Torrance, Jr.

During the past two years, the authors have been investigating this subject, in order to determine empirical formulas which would represent the average practice of American manufacturers, in the rating of gas engines of the stationary type. Data sheets were sent to all the prominent manufacturers and to the majority of chief engineers operating gas-power installations, with the request that these sheets be filled in. The information called for was the size, indicated horsepower, brake horsepower, revolutions per minute, kind of gas used, various efficiencies, etc., for all the standard makes of internal-combustion engines of the four-stroke-cycle, stationary type only, that are at present manufactured in the United States.

As a result, valuable data on some six hundred different sizes and types of machines were obtained, and from this information, in addition to as many other data as could be found in various engineering publications, textbooks, etc., curves and equations were worked out, showing the average practice current in America at the present time.

In addition to these curves and formulas, relating strictly to the average rating of stationary engines, the authors have been able to derive an efficiency table for American practice similar to the one derived some years ago by Güldner for German practice, which was the first object of this investigation. This table will appear in a later article.

The types of stationary engines to which this work is entirely confined, are:

Single-acting horizontal	Single-cylinder, Twin-cylinder
Single-acting vertical	Single-cylinder, Two-cylinder, Three-cylinder, Four-cylinder
Single-acting tandem	Single, Twin
Double-acting horizontal	Single-cylinder, Twin-cylinder, Tandem, Twin-tandem

The principal gases used are: Producer gas, from anthracite and bituminous coals, coke, lignite, oil, peat and wood; illuminating gas, from uncarbureted water gas, carbureted water gas and coal or bench gas; natural gas, including that high in hydrogen, that low in hydrogen and average composition; blast-furnace gas, coke-oven gas and oil gas.

The fuel oils used are: Gasoline, kerosene, crude oil and fuel oil.

Rating for Horizontal and Vertical Engines

Due to the large number of variable factors entering into the design and rating of stationary gas engines, it seemed at first impossible to derive any formulas which would take into account all of these variables with any degree of accuracy. However, it was found that empirical formulas could be obtained, representing an average of American practice and, although not applying in every detail to any one set of engines, yet they show to a nicety wherein lies the safe and sane design.

In order to determine average curves for gas-engine rating it is necessary to consider several fundamental principles, such as the type of engine, horizontal or vertical; arrangement and number of cylinders; kind of fuel used; volumetric, thermal and mechanical efficiencies, etc. These facts are all accounted for in the curves, which are derived in logical order.

Determination of Rated Brake Horsepower

The rated brake horsepower (b.hp.) may be considered as a function of the product d^2ln, where d is the diameter of the cylinder in inches, l the length of the piston stroke in inches, and n the revolutions per minute.

Figs. 1 to 7 show the average, maximum, and minimum curves obtained for the various gases and fuel oils, by plotting the values of d^2ln against the normal brake horsepower per cylinder per end (manufacturer's rating). The equation of each average curve is as follows, in each case representing engines employing the four-stroke-cycle and of the stationary type only.

For engines using producer gas,

$$b.hp. = \frac{d^2ln}{18{,}500} - 2$$

(Average for all values, Curve 2, Fig. 1.)

$$b.hp. = \frac{d^2ln}{17{,}900} - 1$$

(Average for single-acting horizontal and vertical engines, Curve 4, Fig. 1.)

$$b.hp. = \frac{d^2ln}{20{,}600} - 4$$

(Average for double-acting horizontal gas engines, Curve 5, Fig. 1.)

For engines using natural gas,

$$b.hp. = \frac{d^2ln}{15{,}200} - 5 \text{ (Curve 2, Fig. 2)}$$

For engines using illuminating gas,

$$b.hp. = \frac{d^2ln}{15{,}700} - 2 \text{ (Curve 2, Fig. 3)}$$

For engines using blast-furnace gas,

$$b.hp. = \frac{d^2ln}{21{,}000} - 5 \text{ (Fig. 4)}$$

For engines using gasoline,

$$b.hp. = \frac{d^2ln}{16{,}400} - 0.5 \text{ (Curve 2, Fig. 5)}$$

For engines using oils and distillates,

$$b.hp. = \frac{d^2ln}{21{,}875} - 0.75 \text{ (Curve 2, Fig. 6)}$$

In Fig. 7 are plotted the average curves for all the fuels for the purpose of comparison.

In this way the normal rated brake horsepower of an engine can be determined when the cylinder diameter, stroke, revolutions per minute and kind of fuel are known.

In order to determine the relation existing between the revolutions per minute and brake horsepower, curves (Figs. 8 to 11) were plotted with revolutions per minute as abscissae, and brake horsepower per cylinder per end as ordinates. An average curve passed through the points for each type of engine takes the form of a rectangular hyperbola, the equation of which can be readily determined.

The results are as follows: Single-acting vertical engines, single and multi-cylinder,

$$r.p.m. = \frac{5368}{b.hp. + 14} + 176 \text{ (Fig. 8)}$$

Single-cylinder, single-acting horizontal engines (Fig. 9),

$$r.p.m. = \frac{3020}{b.hp. + 9} + 128 \text{ (for gasoline)}$$

$$r.p.m. = \frac{6580}{b.hp. + 21} + 131 \text{ (for gases)}$$

Single-acting tandem engines,

$$r.p.m. = \frac{3650}{b.hp. + 4.5} + 156 \text{ (Fig. 10)}$$

Double-acting horizontal engines,

$$r.p.m. = \frac{9500}{b.hp. + 29} + 72 \text{ (Fig. 11)}$$

It will be noted that there are two distinct curves on Fig. 9, one for gasoline and one for gases, showing that for a given brake horsepower per cylinder per end the gasoline engines have a smaller number of revolutions per minute than those operating on gases. This fact is

*This series of articles is the result of a thesis investigation made under the direction of Professors C. F. Hirshfeld and H. Diederichs, of Cornell University.

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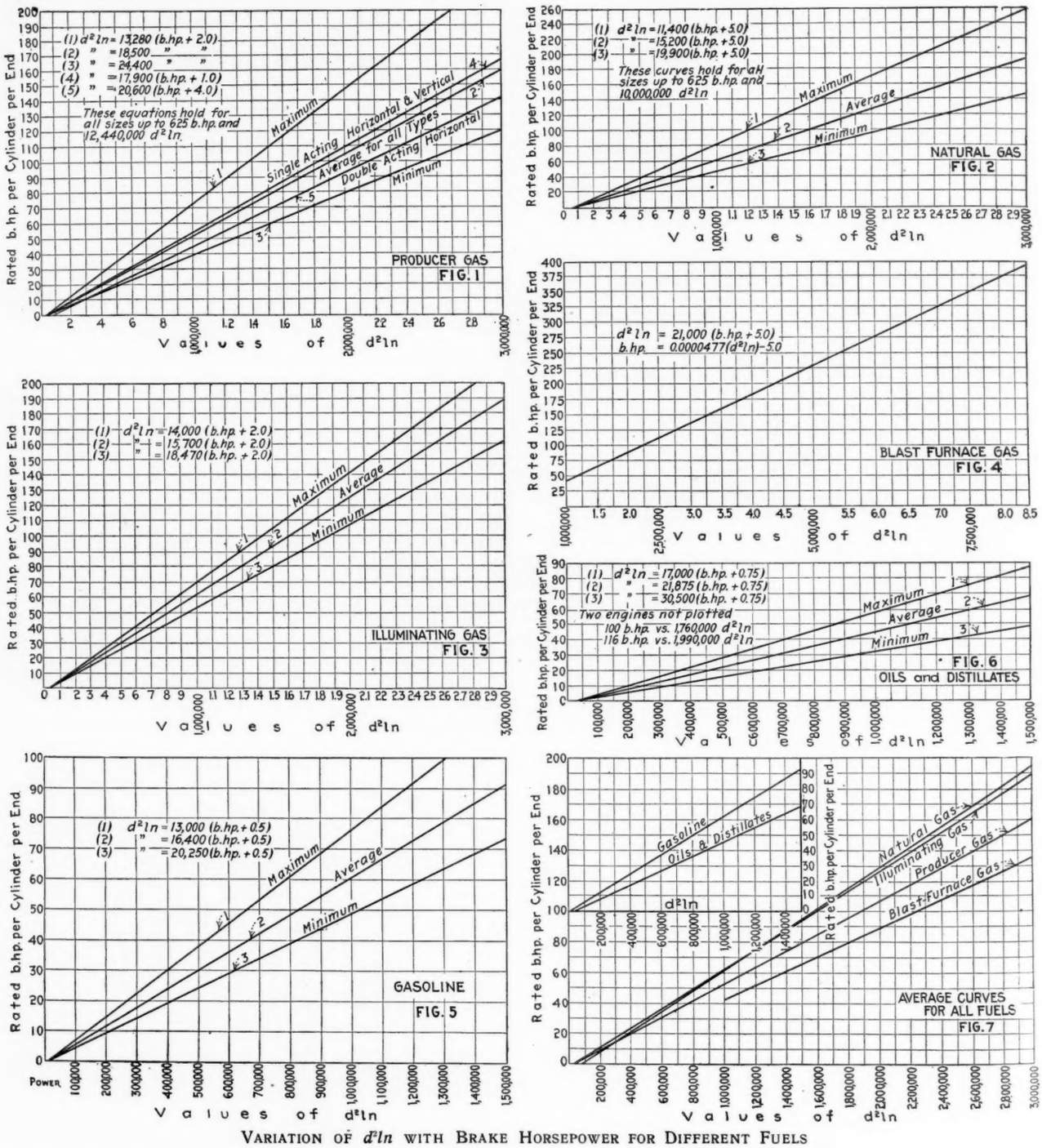
accounted for in two ways: first, that in small gas engines, the inlet valve is usually automatic, thereby reducing the charge volume and hence the speed, and, secondly, that some makers use the same engine for both gasoline and gases, by simply changing the valves. The gasoline engine will have a lower number of revolutions per minute, a larger d^2l, and a lower volumetric efficiency, the latter due to automatic inlet valves and to throttling losses on account of friction in the carburetor and pipes. The gasoline engine will also have a lower

keep the d^2ln values constant for a given horsepower output. From a study of the preceding curves it will be noted that the d^2ln values for gasoline and illuminating gas are almost the same, showing that the d^2l values for gasoline must be larger than for other gases.



VARIATION OF d^2ln WITH BRAKE HORSEPOWER FOR DIFFERENT FUELS

line has a high heat value and therefore requires a lower speed than the fuel gases, which have much lower heat values.

Assuming two engines developing the same brake horsepower, one operating on gas and the other on gasoline, the following facts, which a study of the curves will show, at once become apparent. The thermal efficiency, due to heat lost to the jackets and to a lower compression pressure.

In order to increase the volumetric and the thermal efficiencies, the manufacturers have attempted to correct the foregoing losses by increasing the cylinder sizes in gasoline engines and decreasing the revolutions per minute in order to

Another important fact is that in a gasoline-vapor mixture, there are apt to be small drops of gasoline, surrounded by vapor films, the latter only being explosive. Due to this imperfect mixture, the cylinder volume has been increased in order to admit more volume charge, thereby increasing the thermal efficiency.

Having determined the brake or de-

veloped horsepower, the revolutions per minute and the kind of fuel used, the cylinder diameters and length of stroke must next be found.

Determination of Stroke and Diameter

The definite relation between the cylinder diameter (d) in inches and the length of stroke (l) in inches, is shown in Fig. 12, from which equations were derived.

$$d = 0.91\,l - 0.45 \qquad \text{(Curve 1)}$$

For single-acting horizontal engines, single cylinder,

$$d = 0.667\,l + 0.4 \qquad \text{(Curve 4)}$$

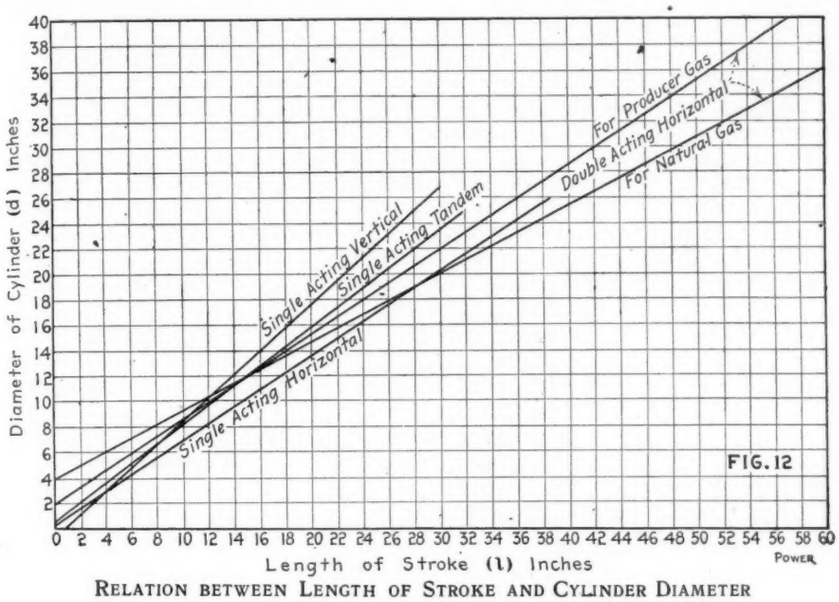
For single-acting tandem engines,

$$d = 0.772\,l + 0.55 \qquad \text{(Curve 2)}$$

For double-acting horizontal engines,

$$d = 0.533\,l + 4 \qquad \text{(Curve 5)}$$

$$d = 0.667\,l + 2 \qquad \text{(Curve 3)}$$



Relation between Length of Stroke and Cylinder Diameter

These equations follow the straight-line law, $y = ax + b$, where b is the y intercept, a the tangent of the angle made with the horizontal and $y = d$ and $x = l$.

For single-acting vertical engines, single and multi-cylinder,

From the preceding equations, the length of stroke (l) can be determined in terms of the cylinder diameter (d) and therefore gives a method for determining the final unknown in the various equations, relating to engine rating.

Problem

Assume a 100-b.hp., single-acting, single-cylinder, horizontal engine, operating on producer gas, and running at its normal speed for rated load. To determine the dimensions of this engine by means of the preceding equations:

From equation 2, Fig. 1,

$$b.hp. = \frac{d^2ln}{18{,}500} - 2$$

or

$$100 = \frac{d^2ln}{18{,}500} - 2$$

Hence,

$$d^2ln = 1{,}887{,}000$$

From equation 1, Fig. 9,

$$r.p.m. = \frac{6580}{b.hp. + 21} + 131$$

or,

$$r.p.m. \cong \frac{6580}{100 + 21} + 131 = 186 \text{ approx.}$$

Therefore, $d^2ln \div n = 1{,}887{,}000 \div 186 = 10{,}145 = d^2l$ and $l = 10{,}145 \div d^2$.

But from the equation of curve 4, Fig. 12,

$$d = 0.667\,l + 0.4 \text{ or}$$

$$l = 1.5\,d - 0.6$$

Substituting this value of l in the equation $l = 10{,}145 \div d^2$

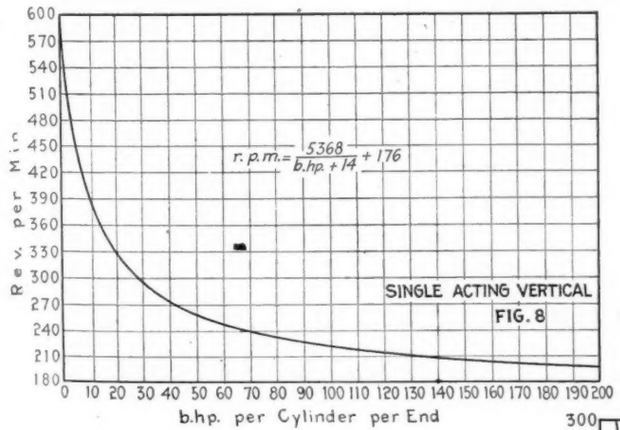
$$d = \frac{0.667\ (10{,}145)}{d^2} + 0.4$$

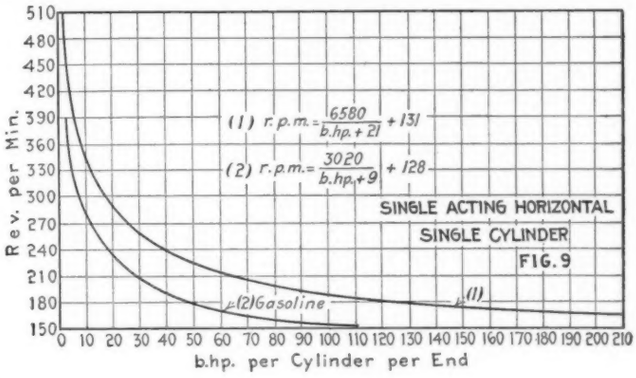
or, $d^3 - 0.4\,d^2 = 6766.715$

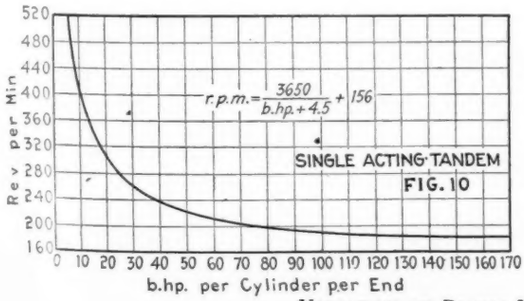
whence, solving by inspection, d is approximately 19 in. Therefore,

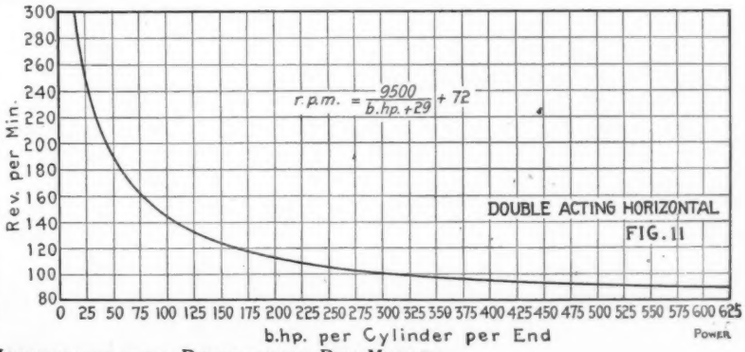
$$l = 1.5\,d - 0.6 = 28\ in.$$

The required engine dimensions then are diameter of cylinder = 16 in.; stroke = 28 in.; revolutions per minute = 186, and brake horsepower (total) = 100.




Rev. per Min.
(1) r.p.m. = 6580 / (b.hp. + 21) + 131
(2) r.p.m. = 3020 / (b.hp. + 9) + 128
SINGLE ACTING HORIZONTAL
SINGLE CYLINDER
FIG. 9
(2) Gasoline
(1)
b.hp. per Cylinder per End





Variation of Brake Horsepower with Revolutions Per Minute

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Heating and Ventilating Park School, Rutherford, N. J.

BY CHARLES A. FULLER

The use of hot-air furnaces for heating and ventilating is gradually being abandoned except in small residences. Here they are probably better adapted for the work they have to perform than the more recent steam, vapor or hot-water heating plants. In the larger residences and schools, particularly where a definite amount of ventilation is necessary, the hot-air furnace is of little value.

Often a fan has been used to force the proper amount of air through the furnace and into the rooms with bypass dampers arranged to control the temperature. Sometimes this has been fairly satisfactory, but generally is a failure. It is difficult to obtain the proper temperature regulation and nearly always there is an odor of coal gas in the rooms at times. The air also lacks the proper humidity and contains considerable dust which is unavoidable with furnaces.

The heating equipment in the Park School at Rutherford, N. J., is of the type described and steps are now being taken to replace it by an indirect steam plant. The accompanying drawings show the general arrangement of the new layout as changed from the old system.

Originally five separate hot-air furnaces were in the five chambers where the banks of reheaters are now shown. These were all fired from a central corridor, the fire doors opening through the brickwork. Considerably more coal was necessary to keep the five separate furnaces in operation than would be burned if the firing were done in one central boiler.

The hot-air system is also supplemented by a low-pressure direct-steam system. Direct radiation is installed in each room and supplied from the old boiler shown in Fig. 1. The amount of radiation in each room is sufficient to take care of the heat loss from the walls and windows with no allowance for air change.

In each of the division walls shown in the plan between the fan room and the plenum chamber was installed originally a large propeller fan belted to an alternating-current motor. These fans served to force air through the furnaces and up into the rooms, but were seldom used. Each hot-air flue over the top of the furnaces had a bypass and a mixing damper to control the temperature.

The five furnaces are to be replaced by a 70-hp. boiler set beside the present boiler, which is to supply the tempering coils and reheater stacks.

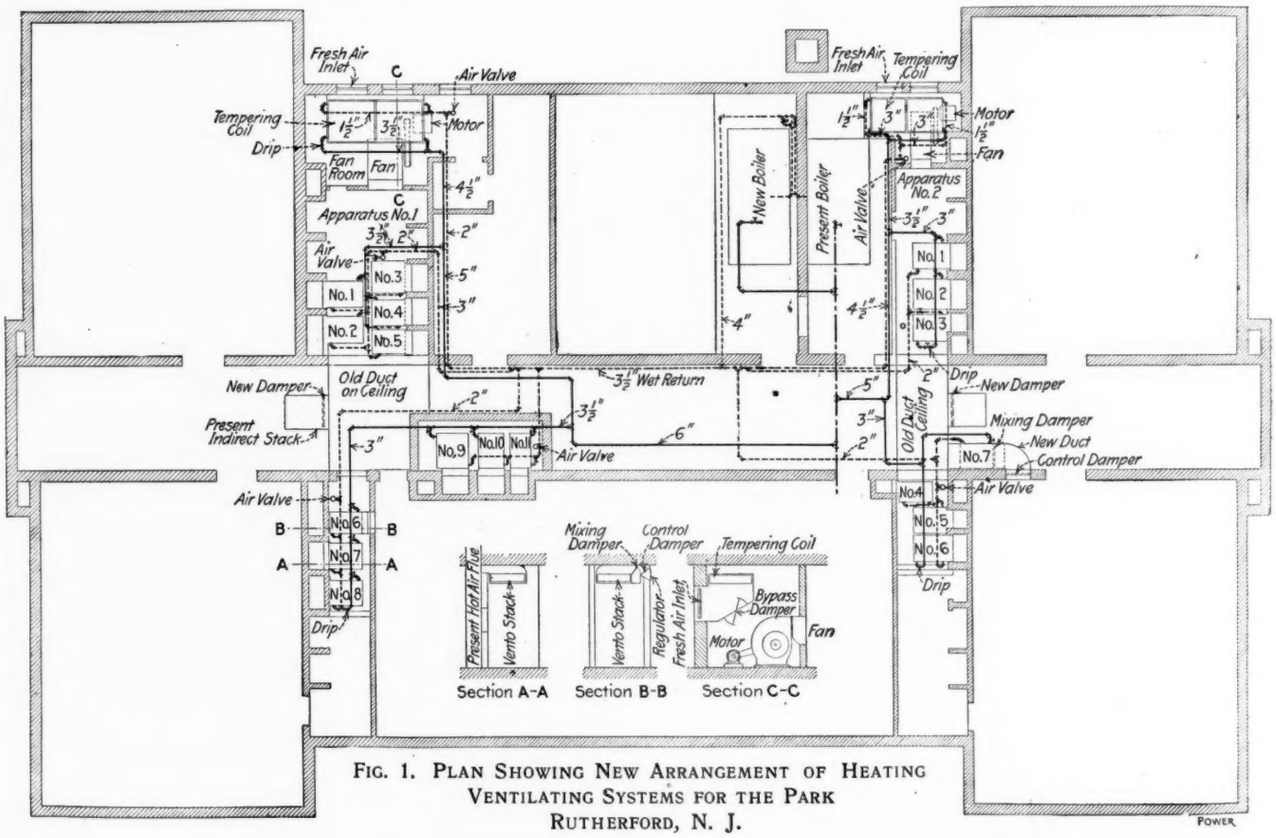


FIG. 1. PLAN SHOWING NEW ARRANGEMENT OF HEATING VENTILATING SYSTEMS FOR THE PARK RUTHERFORD, N. J.

The two propeller fans are to be replaced by two multivane fans, chain-driven by alternating-current motors. The air is to enter through a tempering coil composed of one bank of Vento radiation hung horizontally about 12 in. from the ceiling. It will be inclosed on the four sides by a galvanized-iron casing with its top left open and the bottom connecting with the fresh-air inlet, as shown in the section CC. The air must then pass in through the fresh-air inlet and up through the tempering coil into the fan room from which the fan takes its supply. Thus arranged the tempering

coils will be 24 in. above the water line of the boiler, which permits the condensation to be returned by gravity.

The fans will discharge through the partition walls into the plenum chambers formed in the space formerly occupied by the hot-air furnaces. These chambers are to be as nearly air-tight as possible, the openings left by removing the furnaces, fire doors, smoke flues, etc., to be bricked up and sealed. Inspection doors will be left in each chamber.

At the base of each hot-air flue in the plenum chambers will be a reheater stack composed of one bank of Vento radiation. The casings around these stacks will be the same as those for the tempering coils, only reversed. The bottoms will be left open and the upper openings connected through short ducts to the present hot-air flues. The old mixing dampers are to be used, no change in these being necessary.

The air forced into the plenum chambers from the fans will have to pass either up through the reheater stack and into the hot-air flue, or through the opening below the stack into the flue, depending on the position of the mixing damper. If the damper is set midway, part of the air will pass through each opening.

The tempering coil will be large enough to raise the temperature of the air from zero to 50 deg. F when the required quantity of air is passing. A bypass opening with a hand-controlled damper in this casing will allow air to be drawn into the fan room without passing through the tempering coil if desired.

The reheater stacks will be large enough to raise the temperature of the air from 50 to 75 deg. The tempering coils will have thermostatic control, consisting of two Regitherms in the plenum chambers directly beyond the discharge of the fans. These will operate directly upon balanced valves in the steam-supply mains to the tempering coils and the temperature of the air in the plenum chambers will be held at approximately 50 deg. if the outside temperature is lower.

This arrangement will give ample control of the room temperature by means of the mixing dampers which are operated by chains from the rooms. It will also obviate any chance of cold drafts, which can hardly be avoided if the air is heated entirely by the stacks at the base of the flues without using tempering coils.

When the mixing damper is set to pass part of the air through the reheater and part through the bypass below, the two currents will rise through the flue without being thoroughly mixed. If the register happens to discharge the colder stratum of air below the other it will immediately descend and cause a noticeable cold draft.

If the cold air is partially heated by a tempering coil before reaching the reheater, even with the damper set in a mid-position, the draft will be less severe and not objectionable. Two rooms on the basement floor will receive their air supply from this system, one through reheater No. 6 of apparatus No. 1, and the other through reheater No. 7 of apparatus No. 2. The arrangement for introducing the air to these rooms is shown in section BB, Fig. 1. The heater will have a casing open at the bottom, like the heaters for the rooms above, and the top connected to a duct leading directly to the supply register. At the side of the casing a bypass will open directly into the duct leading to the register. At the top of this opening a mixing damper will shut off either the hot air, or the tempered air, unless set in an intermediate position similar to the others.

Besides the mixing damper a control damper in the duct will be arranged to set permanently in a fixed position when the proper amount of air is passed. The supply registers will be as usual, about 8 ft. from the floor, and the vent registers at the floor line.

The vent flues will all combine into two main vent flues in the attic space, passing through the roof and discharging through ventilators. Besides the ventilators, the main vent flues will have aspirating coils, as may be seen in the sectional elevation, Fig. 2. The system was designed by Clark, MacMillan & Riley, consulting engineers, New York City.

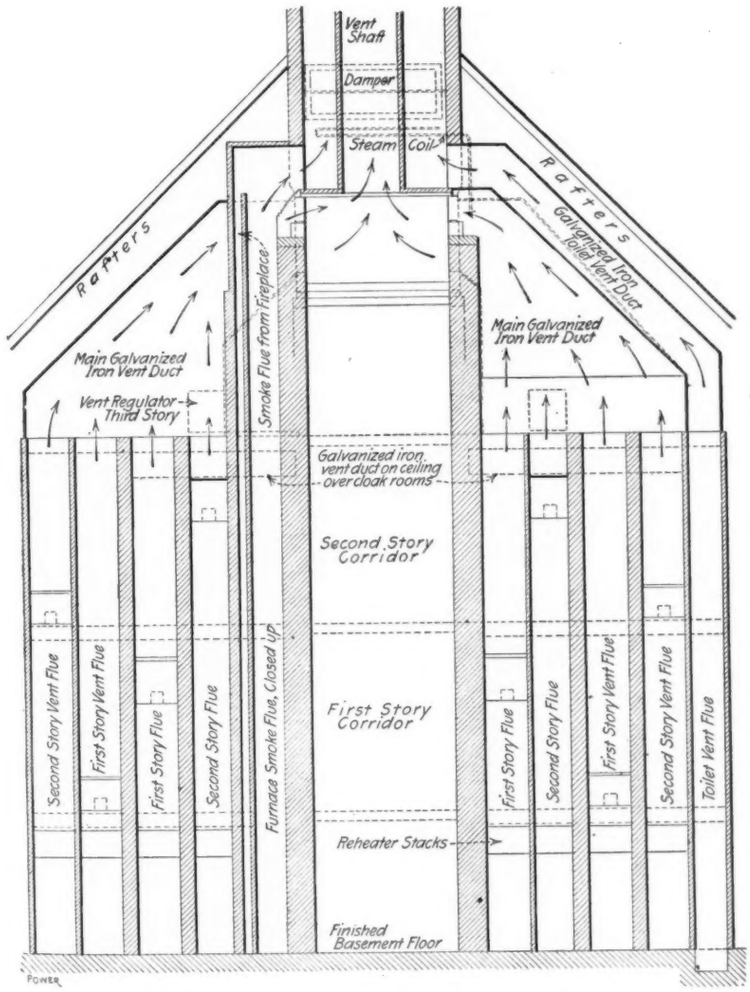


FIG. 2. FLUE SECTION ON LINE A-A OF FIG. 1

Return Trap Is Unsatisfactory

BY W. H. WAKEMAN

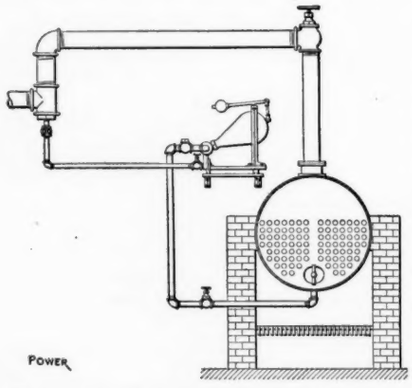
In a certain shop the heating system was unsatisfactory, and a return trap was installed as part of the improvements made. It was located above the water line, as shown in the illustration, and the feed pipe was connected to feed hot water into the boiler. Every return trap must have a live-steam connection to equalize the pressure above and below the water, and it is always a good plan to take steam for this purpose direct from the boiler.

In this case it was not convenient to do this, so a drip from a tee in the main steam pipe was used to supply the necessary pressure. When put into service the device would work well as long as the engine was shut down, but when

steam was admitted to the cylinder, the trap failed to operate, and it became necessary to blow hot water out of the heating system into the sewer.

It was claimed that the failure was due to wet steam, as it was taken out of the drip pocket formed by the lower part of the tee, but this is not correct, as a return trap does not require dry steam. If hot water is mingled with steam coming to a return trap it simply causes more water to go back into the boiler, but it does not interfere with the operation of the trap. It is necessary, however, for full pressure to be obtained in the trap as otherwise water cannot go into the boiler.

Consider the principle which causes a return trap to operate. Pressure in the return pipes of a heating system sends hot water into the trap, which has been relieved of all pressure for this purpose. The weight of water in the trap causes the steam valve to open and admit full



CONNECTIONS WHICH WOULD NOT RETURN CONDENSATION

pressure to the body of it, and the weight causes the water to seek a lower level; hence it runs into the boiler.

Under conditions commonly found in practice, a column of hot water 2 ft. 6 in. high gives a head of approximately 1 lb.; hence if a return trap is set this distance above the water level, there is 1 lb. pressure available to force water into the boiler. If live steam is taken from a drip pipe, as shown in the illustration, and pressure in the main pipe is reduced 1 lb. or more by the engine taking steam, there is no pressure available to send water into the boiler; hence the trap fails to work. As soon as the engine is shut down the reduction ceases and the trap does the work for which it was designed.

In 1895 the maximum distance over which power was transmitted was eight miles and the voltage 5500. Now, says *Cassier's Magazine*, the Southern Power Co., operating six hydro-electric plants and two auxiliary steam plants, sends 121,000 hp. over 1380 miles of transmission line at 50,000 and 100,000 volts.

District Heating Business*

The district heating business is nearly as old as the electric lighting business. As early as 1890 a number of electric lighting companies were selling exhaust steam for heating purposes. At the present time there are over 300 heating plants in the United States. The National Electric Light Association committee gives answers from 100 companies, one-half considering the business directly profitable, while practically all agree that it is of great advantage in connection with electric supply.

While the value of a combination electric and heating system is being recognized more fully as the companies extend their field to include the large commercial establishments formerly considered out of the reach of the central station, it is impossible to find another business so well established and in which so many companies are engaged where one-half believes that the business is yielding no profit.

It is doubtful if a majority of heating companies have the necessary data to make up a reliable operating balance. Heating plants are outgrowths of the electric business and generally are operated in connection with it; therefore the expenses frequently are not separated. The heating revenue is credited to the fuel account and often assumed to be practically all profit; a cost analysis is considered unnecessary. Where an analysis is made, it is many times inadequate, the general expenses, fixed charges and depreciation being omitted.

Failure to show profit may be due to inadequate rates. Many managers consider heating revenue practically all net gain and they establish rate schedules without considering the value of the service to the consumer or of its cost to the company. The popularity of the service shows conclusively its value.

The value to the consumer is easily from 10 to 25 per cent. more than the cost of maintaining his own plant, due to the absence of smoke and dust, to lower insurance rates, to the release of valuable space otherwise occupied by the plant, and to the greater convenience and reliability of the district heating service. The value of the service will generally permit rates based on the cost of supplying live steam, and rates should always be so based, rather than on the not always correct assumption that the steam is a byproduct.

Faulty construction or improper operation may cause a financial loss. The same care should be exercised in designing and constructing a heating system as in the electric-supply system. In general, the distribution system should be designed to secure the maximum density of business with the minimum length of mains. The load on existing mains should be increased and extensions made only where it is certain profitable business can be obtained.

Customers' installations should be subject to supervision. Where flat rates are in use, rigid regulations should be enforced, underground construction should be of best quality to reduce maintenance costs and minimize heat losses. But it must be kept in mind that investment charges on expensive underground construction form a serious item in the cost of district heat supply, and construction costs must not become so heavy that the charges more than offset the resulting operating economies. Where meters are used, a thorough system of inspections and tests is necessary to prevent serious losses of revenue. Above all, adequate records are essential for intelligent and economical operation.

Local conditions have much to do with the success or failure of heating systems; and plants are operated in many places where local conditions do not warrant the investment. This is partly due to the idea that any heating revenue is net profit, and to considerations of policy, such as necessity for occupying the territory to prevent undesirable competition and the ability to offer heating service in connection with electric service. Among the points to be considered in local conditions are location of steam plant, density of available business, probable growth of district, obstructions to underground construction, probable loss of electric-plant capacity and efficiency due to back pressure, length and character of heating season, probable coördination of heating load and electric loads and relative costs of steam coal and domestic coal. These points apply to exhaust heating. Where live-steam heating is contemplated, other considerations enter and the chances of loss become much greater.

Plants depending principally on electrical business may be operating at a loss because they carry undesirable business, such as restaurants, etc., which require summer service. Low rates may be intentionally established to facilitate taking over private plants, with combined heating and electrical load, but this does not seem warranted except where the value of the service to the consumer will not permit higher rates and where the net result is an advantage to the entire electric business.

*Address by President A. D. Spencer, before the National District Heating Association, at Detroit, Mich., July 25.

Power at ½c. per kilowatt-hour is furnished to the Baltimore Copper Smelting & Rolling Co., according to recent testimony given before the Maryland Public Service Commission. The revenue derived from the copper works by the Consolidated Gas, Electric Light & Power Co. was stated to be about $125,000 per year. Power is furnished by the Falls of the Susquehanna.

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POWER

A Short Cut for Boiler Test Calculations

There is always a satisfaction in being able to bring to our readers' attention, means for saving time or effort in connection with their work. For this reason we are particularly gratified at being privileged to present the chart for calculating boiler tests as evolved by F. O. Pahmeyer, of the Heine Safety Boiler Co. (page 116). The ingenuity of the scheme speaks for itself, and did it give only approximate results, it would be worth employing in the majority of cases, but still more fortunately its accuracy is well within the limits of error, attending the taking of observations for the test data. It therefore may be confidently used for calculating any test, however important, and if the engineer still feels that he would prefer to carry out the calculations in the ordinary tedious manner, he will find the chart a useful check on his mathematical work.

Here is a single chart easily contained on one of POWER's pages, yet with it, from any set of boiler-test data, including the average steam pressure, the average feed-water temperature, the factor of evaporation (ascertained from the two foregoing from a table or by calculation) the amount of water evaporated per hour and the amount of coal fired, can be determined the capacity in boiler horsepower, the total equivalent evaporation, the actual and equivalent evaporation per pound of fuel, and the efficiency. By determining the percentages of moisture and combustible in the coal, the evaporation per pound of dry coal and per pound of combustible can be determined, and by correcting for the moisture in the steam, the true amount of water evaporated and the true factor of evaporation can be found.

Special advantages in the use of the chart will be recognized in the means for quickly arriving at results during the test, without waiting until its conclusion to get the refined figures, even supposing the latter to be considered at all necessary. Further, it should encourage more frequent tests of the performance of a boiler plant than would be likely to be made were it necessary to take the time for the various calculations.

It is hardly needful to remind those who have had to do with boiler testing, that this chart, with the explanation of its use, is worth preserving, but this advice may well be heeded by those who, at some future time, are likely to be concerned with it.

Evaluating Coals

It is quite generally appreciated that an indiscriminate selection of fuel for an existing plant is incompatible with the securing of the highest economy. Boiler furnaces are directly designed with consideration for the kind of fuel to be burned and size alone is not the determining factor simply because a certain form of grate bar is used; quite as important is the percentage of ash, for upon this depends the proportion of grate area.

The purchase of coal is not a matter of getting the cheapest on the market regardless of its grade, or heat value. As has just been shown, due allowance must be made for the nature of the furnace, to select the coal for which it is best adapted. Presupposing that the furnace is one originally chosen as suitable for the fuel most readily obtained in the region where it is installed, it is unwise to make any radical departures such as an attempt to burn an entirely different grade of coal or one from a different locality.

Such considerations as the above are fundamental to the trained purchaser of coal, but what is not so generally known, or if known is usually unheeded, is that coal from the same region and even the same vein, may vary very materially in its per cent. of ash content and thereby very decidedly in value. Some very pertinent hints to purchasers of coal are given on page 115, from a report of the Prime Movers Committee of the National

Electric Light Association, a valuable part in which is the extract from the paper by L. P. Crescelius on "The Purchase of Bituminous Coal on B.t.u. Specifications," presented before the American Electric Railway Association. This shows the detrimental effect of high ash content and suggests a reasonable protection of the consumer by imposing penalties that increase rapidly the more the ash content exceeds the prescribed amount.

The body of the report is particularly interesting for the empirical formula it presents whereby a coal may be evaluated on a basis of the percentage of ash it contains. Many have held that such a procedure is unwarranted inasmuch as variation in ash alone is not a safe measure of the value of a coal. Under all conditions it is not, but under the limited conditions that obtain in any individual case it is quite fair to apply, providing the proper relative weight is ascribed to the ash percentage. Within the usual limits, for example, it is shown that 1½ times the percentage of ash, and not the percentage itself alone, should be deducted from the unity, or 100 per cent., value of the fuel.

This simple and easily remembered rule should prove helpful to those having to do with the purchase of coal, and particularly those for whom a calorimetric determination of the value is either out of the question, or at least inconvenient. Moreover, as the report shows, the ash basis is quite as apt to be reliable, for at times the calorimeter may induce very misleading conclusions.

Flange Standards

To have two standards is better than to have no standard, but to have one standard and that the best possible is the consummation devoutly to be wished.

Until recently we had no standard for pipe flanges and flanged fittings. The American Society of Mechanical Engineers and the National Association of Steam and Hot Water Fitters, through joint committees, evolved the U. S. 1912 Standard. The manufacturers claim that they have been ignored in its making and a "Committee of Manufacturers on Standardization of Fittings and Valves" at a meeting held on July 10 adopted the "Manufacturers 1912 Schedule" of flanged fittings and flanges to take effect the first of next October.

We have already published the "U. S. 1912 Standard" (see POWER, Mar. 19, 1912). We shall try to present the "Manufacturers 1912 Schedule" in an early issue. The discussion will then be on the comparative merits of the two. Since the manufacturers have decided to have a uniform schedule the main objection to changing present conditions, the cost of new patterns and catalogs, has apparently been met, and now that this expense, which must in the last analysis be borne by the user, is to be incurred, it is very much to be desired that it should be used to bring about a single standard which would meet all requirements and be acceptable to manufacturers and users alike.

An Ancient Steam Plant

Those who think all the historic old engines are now in museums, if in existence at all, will be surprised to read John S. Leese's description of the Madeley Wood Co.'s plant at Iron Bridge, Shropshire, England, on page 108, and learn that some veritable patriarchs in the power-plant world are still in operation. Quite as interesting as the old beam engines with open-top cylinders are the ancient boilers supplying them with steam at eight to ten pounds pressure. Truly it may be said of the creators of these old plants, "They builded better than they knew."

To us who are quite accustomed to see a plant replaced before it is two decades old, and sometimes not even one, it is scarcely believable that engines which have passed the century mark have not yet outlived their usefulness in the estimation of their present owners. Even as measured by modern standards the fuel consumption relative to the work done is not very high, so the fact that this equipment is still in operation cannot be attributed entirely to sentiment.

Massachusetts Inspection Law Threatened

Not seriously nor permanently; it has done too well and resulted in too general satisfaction for that. Even the manufacturers who opposed it are satisfied of its beneficence and it is serving as a model for other states and cities. But by one of those vagaries of that intangible and incomprehensible bulwark, the law, it is threatened with a period of suspended animation.

The law as passed authorized the governor to appoint one of the members of the Boiler Inspection Department as chief inspector. The governor appointed Joseph McNeill and all was well for several years. Joseph resigned to take a better job and the law does not tell the governor to appoint any successor to him. Hence the perplexity.

One cannot run a boiler in Massachusetts until it has been inspected, vicariously at least, by the chief boiler inspector. But there is and can be no chief boiler inspector until the Legislature repairs its oversight to the satisfaction of the attorney general.

There are several inspectors, insurance and otherwise, on the job, however, and it is to be inferred that the wheels of industry will continue to revolve in the old Bay State until the General Court can get into action, even if they do put some kinks into the legal crowbar that the attorney general has poked between their spokes.

A delectable example of inconsistency is furnished by the adoption by the Interstate Commerce Commission of New Jersey of a rule providing that, "If boilers are equipped with fusible plugs they shall be removed and cleaned of scale at least once every month."

One need not use fusible plugs if he does not want to, but if he does he must clean them once a month. How much safer is a boiler without a fusible plug than one with a scaled plug?

No longer will the vocations of the plumber, bricklayer and carpenter be held by many operating engineers as shining examples of what engineering is not. A school teaching women these trades will be started in New York in October. This ought to convince the disgruntled that even operating engineering has its compensations.

A news item reports a shortage of men in the railroad shops of a large city due to the employees becoming berry pickers at $3 per day. In the same edition a benevolent employer advertises for an engineer at $2 per day. Let's all pick berries.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Water Level Indicator

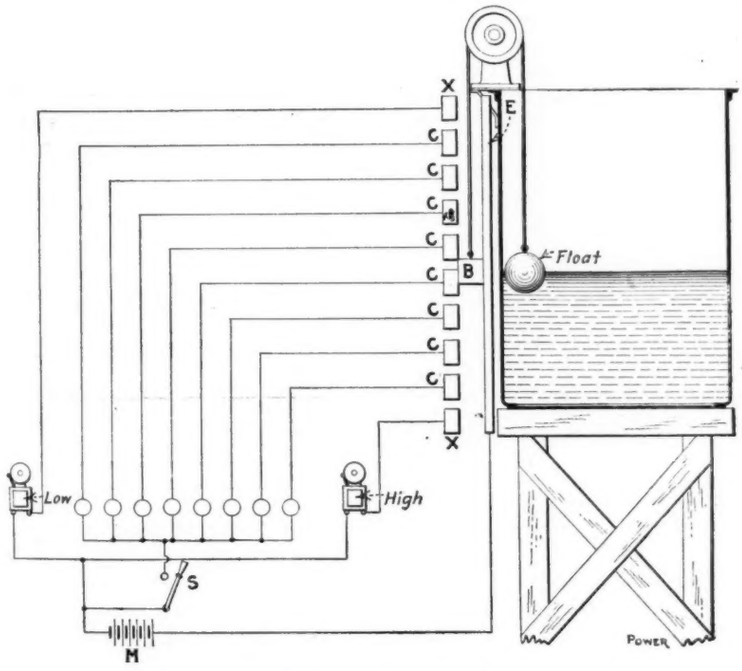
Edward L. Johnson's water-tank gage, shown in the Apr. 23 issue, reminds me of one I recently erected. The one illustrated was used to indicate the water level in a tank about 200 ft. from where the water was used and where it was necessary to know its level in the tank.

The somewhat elaborate arrangement was made possible by using a discarded telephone cable; otherwise its cost might prove prohibitive. In a box are eight low-voltage lamps with a glass front painted black, except for a round disk opposite each lamp, on which the depth of water indicated by that lamp is marked. The bells at each end are connected to the contacts *X* and are in circuit at all times to indicate high or low water. The lamps are controlled by the switch *S* which is only used to ascertain the level of water at any intermediate point.

The contact block *B* is attached to the float by a flexible wire rope passing over a sheave at the top of the tank. This block slides up and down between the two surfaces *E* and *C*. *E* is one continuous strip of iron while *C* is in sections, each connected to a lamp except the top and bottom ones. The contact block *B* is so long that it always touches one contact before leaving another, as otherwise at times the water level would not be indicated. The battery of dry cells shown at *M* operates the system.

P. JUSTUS.

Cleveland, Ohio.



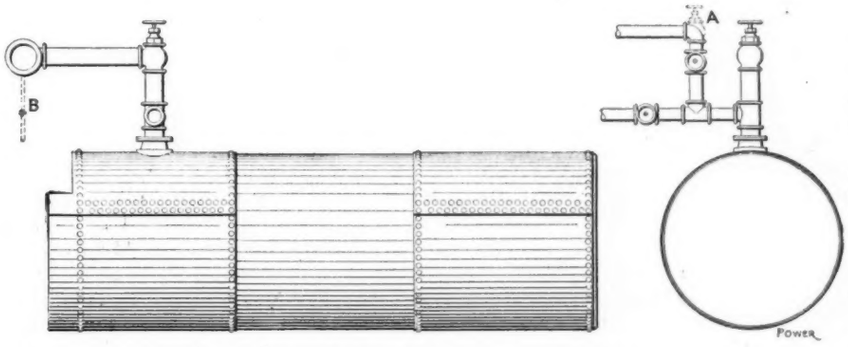
ELECTRICALLY OPERATED WATER LEVEL INDICATOR

Poorly Designed Boiler Connections

The illustration shows the shell of a tubular boiler fitted with an ordinary steam nozzle. Above this is a riser surmounted by an angle valve, but instead of using one piece of pipe for this, the steam fitter (evidently following the designing engineer's ideas) used a nipple, a reducing tee, then another nipple. By means of suitable pipe, this angle valve is connected to a header, out of which steam is taken to operate an automatic engine. The end elevation shows the piping as it appears when viewed from the rear of the boiler. The back of this angle valve is seen, and piping for taking steam from the reducing tee. If an angle valve had been used as indicated by dotted lines *A*, a more direct passage for steam, with two less screwed points, would have resulted.

Steam rises through the nozzle, a portion going to the engine while the remainder passes to a heating system through the smaller pipes, and on a level higher than the boiler. This system has suitable drip pipes, which dispose of the water resulting from the condensation of steam. No danger arises from this arrangement as long as steam is passing rapidly to the heating system, but, should there be only a moderate demand for steam, it would result in slow circulation through these two supply pipes, when there would be nothing to prevent them from acting as connections to two parts of a single pipe system. In this case water would flow back toward the boiler, and entering the riser would be caught up by steam going to the engine and discharged into the header.

If this header had a 1¼-in. drip pipe at each end, as shown in dotted lines at *B*, discharging into the boiler below the water line, the water might thus be disposed of, but, as this header has no drip pipe, the water must go to the engine resulting in a wreck unless large relief valves are provided.



A POORLY DESIGNED BOILER CONNECTION

In all such cases only one pipe should take steam from the boiler, and discharge it into a header large enough to act as a reservoir, and prevent rapid reduction of pressure. Steam for all purposes should

be taken from this header, and the latter should have enough drip pipes to keep it free from collected water.

W. H. WAKEMAN.

New Haven, Conn.

Boiler Explodes

A 22-hp. boiler exploded near here recently at a country sawmill, injuring three men. One of them will die; another will be crippled for life; the other man was blown some distance, but received only slight injuries. It is said that the connections to the water column were clogged.

This and other boiler explosions should be a lesson to all who have boilers intrusted to their care. Had the water column and gage glass been tested the explosion would probably have been prevented. An article dealing with the proper care of water columns and gage glasses might be beneficial.

P. F. ROBNETT.

Kinmundy, Ill.

Worn Piston Rod Allows Oil in Boilers

On taking charge of a plant recently, I learned that considerable trouble had been experienced with oil getting into the boilers. With a view to offsetting this trouble, quantities of sal-soda had been put into the boilers. This in turn had brought about other undesirable conditions, as leaky pipe joints and badly corroded pipes. An emulsion was also formed, which settled to the bottom of the boilers, and was nearly as obnoxious as the oil itself.

An oil separator formed part of the installation, but as the drainage was piped to the sewer, it was impossible to ascertain whether it did its work properly or not. This piping was first disconnected and it was found that little or no oil was discharged. This indicated that all the cylinder oil used in the engines and pumps was being conveyed with the feed water into the boilers.

The separator was opened and a gallon measure full of fine fragments of packing was found lodged in the lower funnel-shaped section leading to the oil outlet.

The mystery was then solved as to what had become of the packing put into the stuffing box of one of the engines. The piston rod of this engine was badly worn and could not be kept packed for even a short time. As it was not possible to shut this engine down long enough for proper repairs, a brass-fiber woven ring was placed in the bottom of the stuffing box next the cylinder. The rod was then packed with good packing and another brass ring inserted next to the follower.

No more packing got through the exhaust, and, after a thorough cleaning, the oil separator did its work. With the judicious use of a specially prepared boiler compound, no more trouble was experienced with oil in the boilers.

EDWARD T. BINNS.

Philadelphia, Penn.

Making Logarithmic Cross Section Paper

When engineers realize the advantages gained by J. Paul Clayton's new method of analyzing indicator diagrams, every progressive one will want to apply the analysis to his engine.

This method is very simple, in that it shows, with little labor and no calculation, such an important factor as quality of steam at cutoff. It allows leaks to be detected with certainty and precision and also enables one to determine the clearance of an engine from a diagram.

A sheet of logarithmic cross-section paper (necessary for the analysis) may not be at hand, and, anyhow, that which can be purchased is not quite satisfactory, as many of the spaces are too large for close estimating. That made as illustrated gives best results. Tack the paper and lay a slide rule on it. The rule acts as a straight-edge and indicates where the triangle is to be placed to obtain straight and logarithmically spaced lines.

Most engineers have, or should have, a slide rule, the scales on which are very accurate logarithmic scales. If the double scale on the upper edge, reading from 1 to 100, could be projected vertically across a sheet of paper and then horizontally across, keeping the 1 at the left and bottom. The result would be a very accurate and complete sheet of logarithmic paper of four squares. Equally good results may be obtained by drawing in the principal lines and using the slide to estimate intermediate distances.

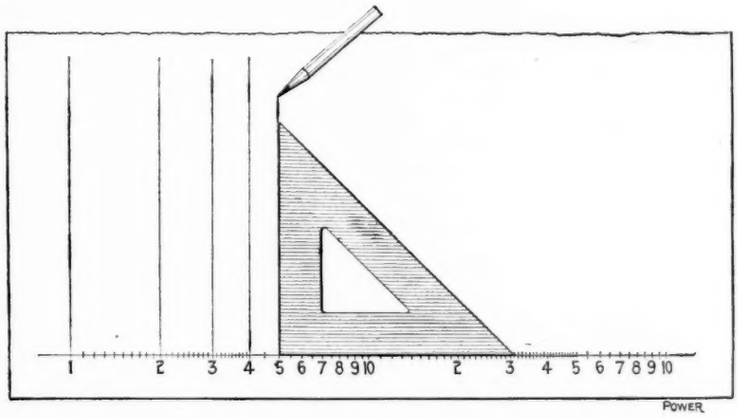
By making this diagram on tracing cloth, light prints may be taken on which to make the actual analysis, but the shrinkage of the blueprint when drying makes it too small for the scale on the slide. This may be allowed for by removing one of the full-size scales from the instruction book, which comes with a slide rule, wetting it thoroughly, and, while still damp, using it as a guide in drawing in the principal lines on the tracing cloth. The tracing-cloth scale will then be too large, but blueprints from it shrink enough in drying so the slide scale exactly fits, and plotting can be done on it as accurately as the slide rule can be read on the corresponding scale.

It will take about one hour to do this work.

G. W. MUNRO.

La Fayette, Ind.

[It now remains for slide-rule or instrument makers to bring out a logarithmically divided triangle for laying off such paper, so that the more expensive and less convenient slide rule will not have to be used for such work.—EDITOR.]



SHOWING MANNER OF LAYING OFF LOGARITHMIC CROSS-SECTION PAPER WITH SLIDE RULE

Why Did the Engine Stop?

On May 9, our high-speed slide-valve engine, directly connected to a 125-kw. direct-current generator, stopped while under full boiler pressure, with the throttle valve wide open. The valve was perfectly set and the cylinder and valve were well lubricated. The exhaust pipe and passages were also free of obstructions.

An effort to turn the engine over with starting bars was unsuccessful. Someone suggested that the flange couplings on the crankshaft be removed, and also the top half of the field and armature, to determine if the cause was magnetic or electric. We could not move the engine, even after the generator and shaft were dismantled. The parts were reassembled and four hours later the throttle was opened and the engine started. Full load was put on and the engine has run well ever since.

What caused our trouble?

GEORGE W. BULLIS.

Des Moines, Iowa.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Clayton Analysis of Indicator Diagrams

J. Paul Clayton has presented to the American Society of Mechanical Engineers a paper of much practical importance. Generally a steam engine is subjected to a test but once in its lifetime, to determine its compliance with the guaranteed performance. Mr. Clayton has made it possible to determine the steam rate with a fair degree of approximation with no other expense or trouble than that of taking and analyzing an indicator diagram. This, at least, if the foundation of his method is sound. It is the invention of the logarithmic diagram which has led to these consequences. The idea of plotting the logarithmic diagram is a real stroke of genius.

Mr. Clayton finds that the expansion and compression lines of the diagram are, for the normal case, true exponential curves and that there is a more or less definite relation between the exponent of the curve, which is simply determined from the logarithmic diagram, and the quality of the steam at the commencement of expansion. The values of the exponents and of the quality are the average of those taken on the two sides of the piston.

The fact that up to the present we have not been able to evaluate even approximately the initial condensation is explained by the number and the variety of factors which influence that quantity during the admission: The size, valve design, relative roughness of the interior surface, the temperature range, length of cutoff, speed, location of ports and port passages, quality of the steam supplied, and the jacketing and lagging. Mr. Clayton has overcome these difficulties by an entirely new departure—calculating the initial quality from its effect after all of these factors have operated; that is to say, after the admission has ceased and, according to the value of the exponent *n*. This is an admirable achievement if it can be demonstrated experimentally that, under the given circumstances, the exponent depends upon nothing but initial quality.

Unfortunately, the relations given between the exponent and the initial quality of the steam do not apply to cylinders provided with jackets, because the jacket influences the phenomena which follow the closing of the admission valve, and it is necessary, further, that the counter-pressure should be very nearly equal to that of the atmosphere. When the back pressure is raised to 30 lb. absolute, for instance, there is a new series of relations existing for the same initial pressure, due to a different temperature range in the cylinder and the consequent alteration of the phenomena occurring after cutoff. On account of these two influences during the expansion, it is necessary to examine each case in particular to determine the relation of the exponent and the quality of the steam at cutoff.

As this method is based entirely upon the information given by the indicator diagram, it is necessary that this should be taken with the greatest precaution to guarantee its exactness. In this respect, Mr. Clayton does not insist enough upon the nature of these precautions. To my mind they are of two sorts:

1. In that which concerns the volume, represented by the abscissas of the diagram. In this connection reducing motions with long cords are to be severely condemned on account of their whipping. The essential condition is that when the piston is exactly at 0.0, 0.1, 0.2, 0.3, etc., of its stroke, the pencil should be also exactly at the same relative point in its stroke. This condition cannot be realized if the reducing motion contains long cords which stretch and contract, or if rigid connections are allowed to have play. The reducing motion should be positive and should be inspected often for lost motion in all its joints, which should take account of the obliquity of the connecting-rods. It is necessary also that the clearance space should be exactly calculated or measured, or, better still, both calculated and measured, that the methods may check each other.

2. In that which concerns the ordinates, or pressures, one should not trust the scales furnished with the indicator, but calibrate the springs for himself with the greatest care, and frequently.

As the two strokes of the piston constituting one revolution are not exactly equal (for the clearance spaces, the degrees of expansion and of compression and the leads are not the same on the two ends) a diagram which has the average values of the two ends is ordinarily taken; and this average diagram, necessarily incorrect, one counts as though it were experimental. But the experimental consumption per revolution is divided into two equal parts with the result that the value of the quality at cutoff resulting from the average is not exact, which can be asserted in advance. What is the degree of error? What consequences will follow this error? It is difficult to answer these questions.

Only one method presents itself for obtaining the greatest exactness possible; that is, to employ two surface condensers, one for each end of the cylinder. On the experimental engine at the University of Liége, to avoid the expense of this complication, dealing, as I was with an unsympathetic administration, I had the valve-gear of the two ends made entirely independent so that they could be adjusted for exactly the same degrees of expansion and of compression, of lead and admission, and the piston was so adjusted as to give exactly the same clearance on both ends. In the course of my experiments, I found, however, differences between the diagrams from the head and crank ends, for which the only probable cause seemed to be the difference in velocity of the piston at the opposite ends of the cylinder, due to the obliquity of the connecting-rod. This convinced me of the necessity of a separate condenser for each end.

I cannot repose absolute confidence in Mr. Clayton's methods. They are only approximations, more or less exact, which, it is true, throw a great deal of light upon the practical operations of an engine and present perhaps more actual usefulness than theories that are more exact, but more complicated. In the issue of July, 1901, of the *Revue de Mécanique*, my assistant, Mr. Duchesne, and I published an article, the object of which was to demonstrate experimentally that the laws of expansion and compression differ from one another. It is evident that they should, since, during the expansion, ordinarily the metallic walls are furnishing heat to the working fluid, while during the compression, or, at least a great part of it, the superheated fluid is furnishing heat to the inclosing metal. All the operations and measurements were made with exceptional care.

The ordinates and abscissas of the indicator diagram are indicated in figures in the article; also the logarithms of the same are given. It is easy, therefore, to plot therefrom the logarithmic diagram. For the expansion, this logarithmic diagram has the appearance of

a straight line without exactly being one. For the compression the curve is so pronounced, especially near the end, that no confusion is possible. The commencement of a hook manifests itself at the end of the compression on the pressure-volume diagram. The novice would attribute this to leakage, but we know that it is condensation. The late George Duchesne demonstrated positively that we were right, by compressing in the same cylinder and under the same condition, noncondensible air with which there was no hook. The only reasonable objection that has been raised is that the slow speed of the engine, less than 60 r.p.m., for a 60-cm. stroke, magnifies the effect of the action of the cylinder wall. This objection is far from invalidating our claim that the law of compression in the steam engine is other than that of the expansion.

Even if it leads only to rough approximation, the work of Mr. Clayton is a step in advance that is certainly novel as well as important.

V. DWELSHAUVERS-DERY.

Liége, Belgium.

A Boiler Inspector's Experience

Your account of the boiler explosion at San Antonio, Tex., attributes it to the combination of a defective steam gage and a locked safety valve. Does it not seem as though anyone who would let such conditions exist is on a par with the fool who "did not know it was loaded"? This is only one of several similar accidents from the same cause in the past few years, notably at Pittsfield, Mass., and on the M. K. & T. R.R. The latter explosion was identical with the San Antonio disaster, although the loss of life was not so great, but the destruction of property was, and all because some shortsighted official thought he could save a few dollars by placing a worn-out and defective gage on the boiler.

While I was a boiler inspector some years ago, I seldom had less than five or six gages and as many defective or corroded safety valves to report weekly. Two cases I recall particularly, the first of which was in North Dakota. I inspected two of the three boilers and on trying one under steam pressure to see if the safety valve was free I found I could not lift it. This led me to take the valves off the idle boilers and test them with the feed pump. One valve opened at 205 and the other at 230 lb., enough pressure to disrupt either boiler. After testing and correcting the gages and slacking off three full turns on the adjusting bolt, the valves were set to operate at a safe pressure. I found on a return visit that the valves would not work at the pressure for which they were set, and no one at the plant knew who readjusted them, as frequent changes were made in the operating crew.

The second case was on a large locomotive boiler in a forge shop in western New York. This boiler was over a furnace used for heating billets and supplied steam at 120 lb. to a steam hammer and other units. At the time of my first visit, Sunday morning, I could not get into the firebox on account of its dirty condition, but I examined the boiler as completely as possible. I reported that the risk should not be carried. The insured would not accept this but arranged to clean out the firebox and take the dome head off if I would examine it again in two weeks; he felt sure I had made a mistake, as it was a first-class boiler, etc. The following is from the report of the defects found on a reëxamination, the external condition having been reported on the first inspection:

"The right side of the furnace has four patches of the following dimensions located at various points on the furnace sheet and all fastened with patch bolts: 15x12 in., 12x9 in., 11x8 in. and 12x6 in.; also three cracks with a total of eighteen 5/8-in. plugs in them. The left furnace sheet has two patches: 23½x11 in. and 16x14 in., also one crack 6 in. long, plugged.

"The back furnace sheet has four patches: 10x6½ in., 10x4 in., 11x5 in. and 16x6 in. This sheet is also badly corroded from the furnace door down to the mud ring and contains pits from 1/8 to 3/2 in. deep. In the door flange are three patches: 8x8 in., 6x4 in. and 8x7 in., also six fire cracks, plugged. The crown-sheet has one patch 13½ in. in diameter with two stay-bolts passing through it, and the additional disadvantage that the patch is on the fire side of the sheet. The flue sheet is badly corroded from the lower row of flues to the mud ring. On the right side of the water leg outside is one patch 6x6 in., and the whole is badly corroded. The joint between this sheet and the front of the water leg leaks, and the left side has one patch 8x7½ in. The back-door sheet shows rivets passing through the mud ring with the heads nearly all eaten away. Internally the boiler is heavily scaled on the tubes and crown-sheet.

"The boiler was given a hydrostatic test and at 140 lb. pressure the side sheets bulged considerably; at 155 lb. the crown-sheet let go in the bracing so that it was impossible to supply the leakage. The steam gage operated in jumps and showed a variation of from 5 to 30 lb. by the test gage. As this examination bears out the opinion formed of this boiler at the first visit, I recommend that the boiler be replaced at once or the insured dropped."

As the engineer told me the safety valve operated at 120 lb., I desired to see it do so, so I put no "gag" on the valve. The test gage showed 155 lb., and when the pump would supply no more water, due to excessive leakage, the valve had shown no signs of blowing. I have found safety valves to stick in the best regulated plants, but as testing them is invariably hot and disagreeable, some engineers take a chance, trusting that when the steam gets to the blowoff point, they can check the draft or put the feed on to hold the pressure down.

F. J. NAYLER.

Cos Cob, Conn.

The V-Thread on the Bolt

L. F. Brown's letter, in the May 14 issue, goes straight to the point in regard to the passing of the V-thread and the final standardization of nuts. I agree with him that this question has long caused much worry and confusion among those associated with machinery.

Simplicity and accessibility in the construction of a machine are desired by the purchaser, or engineer who is to operate it. Consistency demands that this question be given immediate attention and adjustment, since bolts and nuts are common to all machinery and ought to be interchangeable, size for size for all purposes. I cannot see why a square nut is made at all, since it is just as easy to stamp a hexagon nut as a square one. Of course, bolts and nuts of this style can be made in as many different grades of finish and material as they are now, so there is no real ground for objection on this point. It would be a pleasure to everyone to be able to renew a nut on the first trial even with any stray nut picked up in the plant, and also to remove all nuts of a certain size without changing wrenches, as Mr. Brown says.

It is becoming more and more rare for the average manufacturer to make the bolts, nuts and similar parts that enter into his finished product, and more and more are such parts being purchased from those making a specialty of producing them in large quantities. Consequently a sane standard should be established; constant protests will soon bring this about.

LLOYD V. BEETS.

Nashville, Tenn.

Negative Lap on Double Eccentric Corliss Engines

In the May 21 issue under "Inquiries of General Interest," your reply to inquiries of "J. K." and "A. D. K.," regarding negative lap of steam valves on double-eccentric Corliss engines, is not in accord with modern practice nor with my experience with this type of engine.

There may be a few instances, especially on double-eccentric engines in the early days of their manufacture, when the

steam valves on Corliss engines were not given more than $\frac{1}{32}$ in. to $\frac{1}{16}$ in. port opening, or negative lap when the wristplate was central. With the amount of port opening in the central position which you suggest in reply to these inquiries, the latest possible cutoff would be about 55 per cent. of the stroke, which is not a "long range cutoff" from a present-day viewpoint. Corliss engines which have been kept abreast of the times by their manufacturers, and especially within the last 10 or 12 years, have a much larger port opening in the central position than you mention, which permits setting the steam eccentric at so small an angle ahead of the crankpin with a direct motion, that cutoff may take place quite late in the stroke, and a cutoff of 82 per cent. of the stroke or even a little more is easily obtained.

With care, the steam valves and steam eccentric can be so adjusted that the steam valve closes just before the exhaust valve at the same end opens. It is not contended that this is economical by any means, as terminal pressure may be as high as 85 or 90 per cent. of the initial pressure, but in modern practice conditions are such that at times engines are compelled to take care of peak loads that even 10 years ago would have been considered dangerous. But the condition must be met and it is generally considered more economical, all things considered, to waste steam on an overload for an hour or two during the day, than to provide the necessary equipment to take care of this excess load under economical conditions, and have the units running under a wasteful fluctuating underload for a greater period of time, or else stand idle for the greater part of the 24 hours. The great range of cutoff now used on engines in power houses, rolling mills and other severe work, is the result of a demand on the manufacturer caused by the conditions to be met.

With the ordinary single-eccentric engine, as soon as full load is exceeded by a small margin, the engine becomes a fixed cutoff engine, operating like a plain slide-valve engine having its speed regulated by a throttle valve (much the same as a locomotive), but which is always open to the limit; therefore when the load becomes so great that it over-balances the steam pressure, the speed reduces with serious results.

Thus was the double-eccentric developed on Corliss engines, which was improved so that engine speed is practically constant at all points of cutoff from no load to 60 per cent. or more overload. But to get this late cutoff to take care of peak loads, the angle of the steam eccentric ahead of the crankpin was gradually reduced to a very small angle, and as the angle of the eccentric was retarded, it was necessary to increase the port opening on the steam valves to a considerable extent, and also lessen the lap, thus ignoring the old injunction that unless a valve had considerable lap it would not be steam-tight.

I have set the valves on Corliss engines equipped with double eccentrics throughout a wide range of sizes and in no instance has the port opening with the wristplate central, been less than $\frac{13}{32}$ in. which was on an 11x30-in. direct-connected engine running 165 r.p.m. The steam valves had $\frac{3}{16}$-in. lap in extreme position.

On an engine with an 84-in. cylinder the valves were given no less than $1\frac{3}{8}$ in. port opening with a correspondingly small lap. It must be understood that with this late cutoff care must be taken that the valve-gear unhooks at all points of cutoff and that the dashpots seat properly; otherwise, the steam valve will remain open at any given end until the exhaust valve at that end opens, thus allowing steam to pass through the cylinder directly to the exhaust.

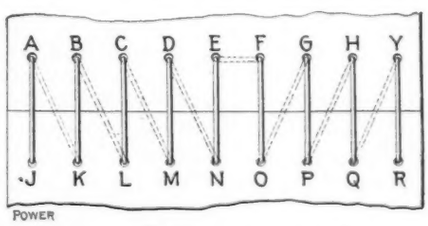
When I refer to the wristplate being "central" I refer to the position of the valve-gear when the valve is at the middle of its travel, with both steam valves hooked on. However, Corliss engines are becoming common now which do not have a wristplate at all, especially to drive the steam valves, these being connected together through their steam levers by a steam rod, and the hook rod with its releasing mechanism attached to the forward steam lever.

GEORGE H. WALLACE.

Racine, Wis.

Wire Lacing for Belts

Mr. Fries, in the issue of Apr. 16, speaks of the tendency of wire lacing to pull the ends of the belt out of line. W. G. Hawley's letter in the issue of May 28 shows that he noticed the same thing, but I think Mr. Hawley's lace will be more likely to bend, which in time will cause failure, than the one herewith illustrated. I have used this lacing with much success. The bending in the joint is very deleterious and the ends of the



POWER

STYLE OF WIRE LACING FOR BELTS

lacing should be very tight together, and the holes should not be any farther from the end of the belt than necessary. With Mr. Hawley's lace the wire is longer on the back from hole to hole than if it were straight with the belt. This tends to make the joint bend more easily.

I make all the holes first, using a punch about $\frac{1}{8}$ in. in diameter and punching the holes $\frac{1}{2}$ in. apart. In drawing the lacing tight with pliers, I always use them on the end of the lace only, as they would otherwise nick the wire and cause it to break. The end chewed by the pliers will be cut off, so there is no harm done in this way.

To lace this joint, double the wire in the middle and put the ends through adjoining holes, as *E* and *F*. From the back side pull both ends through till the loop is up tight on the belt, then take one end across on the face to the opposite hole as from *F* to *O*, then back to *F* and across to *O* again and then from *O* to *G* across the back, and so on to *R*. From *R* run to *Y* across the back, then through *Y*, and pull the wire tight in the direction of *R*. Finally cut off the ends fairly close and hammer them down with the rest of the lacing. Treat the other end the same way.

This style of lacing equalizes the lateral strain and prevents disalignment of the belt. I have also had success with annealed-iron wire when the regular wire lacing could not be obtained.

CLIFFORD SMITH.

Midland, Calif.

Standard Indicator Cocks

The editorial on standardizing indicator cocks is timely. I realize this very much as I have made a business of indicating engines as a side issue to my regular work, and in many engines I found that the indicator could not be attached without repiping, as sometimes there is no valve except the 3-way cock. I believe three standard sizes of connections are in use in the various makes of indicators, probably because each designer has his own idea as to what the size should be, and as a cock is furnished with each instrument, it is presumed that different sizes make no trouble.

Nearly all engine builders fit their new engines with indicator piping, and I would suggest that they get together and decide on one standard size of connection, and to accommodate indicators that are not made to that standard, furnish a nest of two or more bushings so that the same 3-way cock may be used with three indicators of different make. But if the indicator manufacturers get together with the engine builders, no extra bushings would be needed.

Under present conditions I find these bushings necessary, as often a job is lost through having to wait till some convenient time to repipe the engine. Some standard for indicator connections should be established.

J. CASE.

Hyattsville, Md.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Flame in Boiler Tubes

Do the gases of a boiler furnace continue to burn with flame in passing through the tubes of a boiler?

J. D. M.

Little, if any, when the tubes are clean, as combustion ceases as soon as the temperature of the gases is reduced to a certain point by transfer of their heat to the boiler. Incombustible matter, carried along like incandescent dust, may remain luminous after being swept along with the heated gases and be mistaken for flame of combustion after the combinations of combustion have ceased.

Boiler Joints

How many kinds of riveted joints are used in boiler work and what is the effective strength of each compared with the solid part of the boiler plate?

P. C.

The different kinds of boiler joints and their approximate efficiencies, as usually designed in good practice, are as follows:

	Per Cent.
Lap-joint, single-riveted, longitudinal or girth	57
Lap-joint, double-riveted, longitudinal or girth	74
Butt and double-strap joint, double-riveted	82
Butt and double-strap joint, triple-riveted	87
Butt and double-strap joint, quadruple-riveted	93

Approximate Rule for the Transmitting Capacity of Leather Belts

What rule can be given for estimating the number of horsepower which leather belts are capable of transmitting, under average power-plant conditions, where the belts run over cast-iron pulleys 24 to 60 in. in diameter?

G. B. D.

The horsepower which a belt is capable of transmitting depends on its tension, strength, speed and frictional adhesion to the pulleys. No exact rule can be quoted for use in all cases, because the conditions are variable, but a good rule for estimating the transmitting capacity of leather belts as used in average practice is to allow that one horsepower is transmitted per inch width of single-thick belt for travel of 785 ft. per minute, which corresponds to the peripheral speed of a 30-in. pulley making 100 r.p.m., from which the proportionate power due to different sizes and speeds of pulleys and widths of belt are readily calculated by the formula:

$$N = \frac{D}{30} \times \frac{S}{100}$$

where

N = Number of horsepower transmissible per inch width of single belt;

D = Diameter of pulley in inches;

S = Speed in revolutions per minute.

For double belts allow 90 per cent. more.

Smoke Stack Joints

For greatest durability of a sheet-iron or steel smoke stack which is exposed to the weather, should the girth joints be made with the lower end of each course set inside or lapping outside of the course below?

A. H.

Each girth joint should have the upper course set inside of the course below it, for when a course laps over the course below it, fine soot will sift through the joint from the inside of the stack, and becoming moist will cause discolored streaks of soot on the outside, forming a deposit which will eat away the stack paint and cause the material of the stack to corrode very rapidly.

Piston Rings and Leakage

Before it is cut, how much larger should a piston packing ring be turned, than the diameter of the cylinder in which it is to be used?

How can it be determined when the valve or piston rings of a simple slide-valve engine leak?

G. W.

Piston rings for cylinders up to 20 in. in diameter are generally turned solid about ¼ in. larger in diameter than the bore of the cylinder, and for larger cylinders the rings are turned about 0.1 per cent. larger than the bore of the cylinder, before being cut to spring them in place.

The best way to determine whether a slide valve leaks is to throw the crank on the dead center toward the cylinder, remove the cylinder head, disconnect the valve and set and block the valve so as to take steam only on the crank end of the cylinder and with the exhaust open to the head end. If the valve leaks, steam will escape from the port on the head end. If the piston leaks, steam will be seen to blow past the piston rings. For testing leakage of the piston at an intermediate point of the stroke, hold the piston at the desired point by blocking the crosshead.

Force Exerted by Expansion or Contraction of Iron

How can the force exerted by the expansion or contraction of iron when heated or cooled be estimated? If the bolts which hold together the halves of a flywheel hub are each 12 in. long and 1½ in. in diameter, and are set up tight by a wrench, when the temperature of the bolt is 212 deg. F., how much tighter will each bolt hold after cooling down to 60 deg. F.?

D. W.

The force exerted by expansion would be equal to that which would be required as a compressive force to bring the expanded body back to its original volume; and conversely, the force exerted in contracting would be the same as the force required to expand the contracted body to its original dimensions. The coefficient of longitudinal expansion of iron being 0.0000067302 of its length for one degree Fahrenheit, then, as expanding from 60 deg. to 212 deg. would be through 152 deg., the lineal expansion of 12 in. of iron would be

$$152\ deg. \times 0.0000067302 \times 12 = 0.01228 + in.$$

From the formula

$$E = \frac{Pl}{K\lambda}$$

where

E = Modulus of elasticity (22,000,000 for wrought iron);

P = Tensile stress applied;

l = Length under consideration (12 in.);

K = Sectional area (for a 1½-in. bolt = 1.767 sq.in.);

λ = Elongation in that length (0.01228 in.).

Then

$$22{,}000{,}000 = \frac{P \times 12}{1.767 \times 0.01228}$$

$$P = \frac{22{,}000{,}000 \times 1.767 \times 0.01228}{12}$$

$$= 39{,}781\ lb.$$

This, then, will be the strain imposed on each bolt in cooling from 212 deg. to 60 deg. F., to which must be added the strain produced in tightening the bolt with a wrench. Some compression always will take place reducing the distance between the bearings of the nut and bolt head, and the strain from contraction is thereby reduced by the percentage which the compression is of the contraction in length that the bolt would undergo with the reduction in temperature if unrestrained.

Study Questions

This Week's Questions
Last Week's Answers

(51) While a hoisting engine is raising a load of 15,000 lb. at 200 ft. per minute, what is the mean effective pressure in the cylinder if its diameter is 20 in., the diameter of the piston rod 3½ in, the stroke 3 ft., the speed 60 r.p.m. and the mechanical efficiency, including the drum and sheaves is 70 per cent.?

(52) If the fuel consumption per indicated horsepower per hour is 1¾ lb., how many tons will be required in 24 hr. for the running of a 6000-hp. engine?

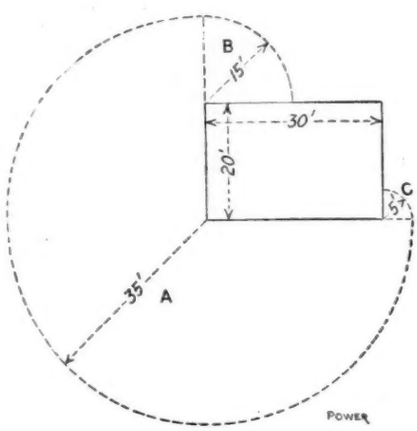
(53) Between the terminals of an unknown resistance x in an electrical circuit the drop in potential is 35 volts and between the terminals of a resistance of 300 ohms, the drop is 50 volts. What is the resistance x?

(54) To what uniform thickness can a 2-ft. sphere be covered with 1 cu.ft. of material?

(55) A steel standpipe for water is 185 ft. high and 20 ft. in diameter. How thick should be its lower plates if the joints have an efficiency of 75 per cent. and the allowed stress is to be 16,000 lb. per square inch?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

(46) As shown by the diagram the extreme swing of the cable is over an area comprising ¾ of a circle of 35 ft.



radius, ¼ of a circle of 15 ft. radius and ¼ of a circle of 5 ft. radius. The area of a circle being πr^2

Area A = ¾ of 3.1416 × (35)² =	2886.345
Area B = ¼ of 3.1416 × (15)² =	176.715
Area C = ¼ of 3.1416 × (5)² =	19.635
Total	3082.695 sq.ft.

(47) Let

x = Age of steam engine;
y = Age of steam turbine;
z = Age of gas engine.

From the conditions of the problem

$$x = y + z \qquad (1)$$

$$z + 5 = \frac{y + 5}{2} \qquad 2z + 10 = y + 5 \qquad (2)$$

$$z + 10 = \frac{x + 10}{2} \qquad 2z + 20 = x + 10 \qquad (3)$$

Substituting value of x from (1) in (3)

$$2z + 20 = y + z + 10 \qquad (4)$$

Subtracting (2) from (4)

$$(2z + 20) - (2z + 10) = (y + z + 10) - (y + 5)$$
$$10 = z + 5 \qquad z = 5$$

Substituting value of z in (2)

$$10 + 10 = y + 5 \qquad y = 15$$

Substituting values of y and z in (1)

$$x = 15 + 5 = 20$$

Therefore the steam engine has been in service 20 years, the turbine 15 years and the gas engine 5 years.

(48) The boiling point of water is 212 deg. F. Then 212 — 62 = 150 deg. is the rise in temperature. At 62 deg. F., 1 gal. of water weighs 8.3356 lb. Since 1 B.t.u. = amount of heat required to raise 1 lb. of water 1 deg. F.

$$8.3356 \times 150 = 1250.34 \text{ } B.t.u.$$

is the heat energy required and 1 B.t.u. being equivalent to 778 ft.-lb.

$$1250.34 \times 778 = 972{,}764.52 \text{ } ft.\text{-}lb.$$

is its equivalent in units of work.

(49) The volume of metal will equal the area of the cross-section multiplied by the length. The area of a circle being ¼ πD^2 or 0.7854 D^2, the cross-sectional area is

$$(0.7854 \times 6.625^2) - (0.7854 \times 5.75^2) = 0.7854\,(6.625^2 - 5.75^2) = 8.5044 \text{ } sq.in.$$

Then

$$\frac{8.5044}{144} \times 12 = 0.7087 \text{ } cu.ft.$$

is the volume of metal and

$$0.7087 \times 480 = 340.176 \text{ } lb.$$

is the weight.

(50) The formula for the space covered by a body falling freely from rest is

$$s = \tfrac{1}{2} gt^2$$

where

s = Space in feet;
g = Acceleration of gravity = 32.2 ft. per second;
t = Time in seconds.

Substituting

$$s = \tfrac{1}{2} \times 32.2 \times 100 = 1610 \text{ } ft.$$

The velocity formula under the same conditions is

$$v = gt$$

where

v = Velocity.

Substituting

$$v = 32.2 \times 10 = 322 \text{ } ft. \text{ } per \text{ } second$$

Heating and Ventilating Engineers Meet in Detroit

Hotel Tuller was headquaraters for the American Society of Heating and Ventilating Engineers during the fifteenth semiannual convention held in Detroit, July 11, 12 and 13. In the absence of President John R. Allen, First Vice-President John F. Hale presided and delivered the address of welcome, concluding with some mention of the object and aims of the society and the advance made during the last six months. The membership now totals 444.

Mr. Hale continued by reading a paper sent by the president from Constantinople on "Heating in Turkey," in which Prof. Allen showed the progress now being made in Turkey as evidenced by the erection of modern office buildings and improved methods of heating. Most Turkish houses are heated by open charcoal fires, or perhaps by a mongol, but in the business section of Constantinople several new buildings have been equipped with modern heating arrangements, and almost all are hot-water systems. As a rule the pipes are small and their arrangement crude, but fortunately not much heat is required in Turkey. Heating a number of buildings from a central plant is new to this country but two installations of this kind are now in progress, one at Armeautkeny in the American school for girls, and the other the writer is installing at Robert College.

Following some routine business, communications were read from the Illinois, New York and Massachusetts chapters, each reporting what had been done since the last annual meeting in January and the topics that had been discussed at the various meetings. Committees on Testing of House-Heating Boilers, Standard Outside Weather Temperature, Ventilating Standards for Motion Picture Theaters, Tests, Compulsory Ventilation and Heating Guarantees reported progress and promised complete reports at the next annual meeting.

In response to an invitation from the National District Heating Association, the convention instructed the board of governors to appoint a committee of five to work with a similar committee from the other society along educational lines, choosing their own subjects and taking up the most urgent current topics.

The committee on the 1912 standard for pipe flanges and flanged fittings spoke of the attitude of some of the manufacturers and their hesitancy about adopting the new standard. A resolution was passed recommending that members of the society and other engineers use and specify the 1912 standard. The election of a nominating committee for officers for 1913 completed the business session.

The tellers reported the following names: George Mehring, Chicago; Joseph Graham, New York; H. W. Whitten, Boston; C. F. Newport, Chicago, and F. R. Still, Detroit.

Papers

In his paper on "Temperature Equivalents of Wind Velocities," H. W. Whitten showed, from a comparison of records that one mile of wind movement per hour, between 40 and 15 deg. plus, requires about the same amount of heat supply as 1 deg. drop in temperature. From 15 to 20 deg. minus, the equivalent of one mile wind velocity is 1.15 deg. This is for ordinary buildings constructed without protected windows. The impact effect of wind of uniform velocity, with the barometer constant, was reported to increase 0.4 per cent. per degree drop in temperature.

"Open Windows with Mechanical Ventilation" was the subject of a paper by Ralph C. Taggart. He sides with neither the advocates of open-window ventilation alone, nor those favoring mechanical ventilation without the use of windows, for the author believes that no ventilating system should be installed, the balance of which is appreciably affected by opening windows. The system should give as good, or better results, when used in conjunction with open windows than in any other way, and the engineer who insists on closed windows is making almost certain the unsatisfactory operation of his apparatus. The author discussed to some length both sides of the question and ended with the above conclusion.

In his paper on "The Time Element in Heating Apparatus," James A. Donnelly presented several charts, showing the time required to heat a cold radiator, the variations in temperature in a concrete factory building and temperature changes in a fan-operated drying room.

John D. Small presented a paper in question-and-answer form on "Office Practice in Estimating Heating and Ventilation," including the subjects of estimating radiation, air changes per hour, hot-air heating and ventilation vs. tempered air and direct radiation, mains as heating surface or covered throughout, vacuum devices in heating systems, standard methods of estimating heating and ventilation, the placing of radiation, and window construction.

Samuel R. Lewis described the heating and ventilation arrangements of the factory of the Defiance Tick Mitten Co., in Toledo. The blast system is used. Fresh air is supplied through special steel casement sash and is drawn through tempering coils and steam-jet humidifiers to the supply fan. The steam supply to the tempering coils is controlled by a thermostat and an air temperature of 60 deg. is maintained. The steam jets are controlled by a sensitive element operating within a range of 5 per cent. from the point at which it is set (about 40 per cent. relative humidity). A minimum of 30 cu.ft. of fresh air per occupant per minute is provided.

A paper on "Humidity in Relation to Heating and Ventilation," by L. C. Soule, dealt briefly with humidifiers and air washers and the power required to provide proper humidity. A paper along the same lines was presented by J. I. Lyle, his topic being "Methods of Automatic Humidity Control for Air Washers." The author describes a system of automatically regulating the humidity by controlling the dew point, or saturation temperature of the air leaving the washer. Saturation is produced by heating the spray water and varying its temperature as much as necessary to maintain a constant dew point under variable conditions of the entering air. Analyses were made with the assistance of the Carrier psychometric chart of the various methods which have been proposed, showing their fallacies, either in being wrong in theory, or impossible practically. Attention was also given to the practical difficulties encountered with bypass dampers and the regulation of the steam supply to the tempering coil.

In a paper on "Brick Drying," H. C. Russell discussed dryers of the so-called progressive type, considering capacity of the machine, time and temperature for drying, construction of kilns and dryer, the heat losses including the British thermal units required to evaporate the moisture, the heat absorbed by the cars and clay, and that lost by radiation; also the amount of waste heat available. To dry each brick requires about 4200 B.t.u. and during the process of waste heat drawing, about 3200 B.t.u. may be recovered, so that only 30 per cent. above the amount obtained from waste heat is required. These figures are based upon the most extreme conditions with an outside temperature of 35 deg.

Following the above paper an animated discussion was started by D. M. Quay on "Upward vs. Downward Ventilation in Theaters." Mr. Quay condemned the mushroom system of introducing air under the seats and drawing it out at the ceiling on account of the contamination resulting from contact with the clothing and perspiration on the occupants. The system should be reversed: fresh air introduced above the breathing line and drawn out at the floor.

S. R. Lewis objected to the downward system on account of opposing currents set up by heating or glass surfaces or perhaps the occupants themselves interfering with the circulation. He favored upward movement as did the majority of those discussing the question.

A. M. Feldman described the ventilating system of a new dispensary building attached to the Lebanon Hospital, New York City. Radiators in the clinical rooms are arranged, direct-indirect, that is, part of the sections of each radiator are inclosed. Fresh air is drawn through screened openings under the windows, passed over the inclosed part of the radiator and out into the corridor through louvers in the bottom panel of the doors, air flow in this direction being induced by exhausting the air from the corridor. The corridor serves as a waiting room for patients, and on account of the numbers usually present requires thorough ventilation.

"Removal of Refuse and Waste by Fans and Blowers," was the subject of an interesting paper by F. R. Still. For economical operation it is very important to know the minimum velocity or volume of air required to convey substances of varying specific volumes and densities as the frictional loss multiplies directly as the square, and the power to drive the fan directly as the cube of the velocity. Mr. Still gives a general insight into the methods which have been employed for years and points out opportunities for improvement. He takes up the general scheme and sizes of piping, the size of fan, proportion of dust separators and the proper form and construction of hoods.

The final paper, by J. M. Stannard, dealt with the heating and ventilating of the Northwestern University buildings at Evanston, Ill., which is accomplished by hot-water forced circulation and direct and indirect steam plants under both vacuum and gravity methods. The paper describes the equipment and arrangement of the plants and includes a table giving operating costs, favoring the steam system.

Entertainment

Detroit's reputation for entertainment was upheld at the present convention. There was plenty to see and do and the committee provided an excellent program. On Thursday afternoon the ladies were taken to Bois Blanc and in the evening all went to Belle Isle. Friday's entertainment consisted of automobile sight-seeing trips for the ladies and in the afternoon the men inspected the plants of the American Blower Co. and the Ford Motor Co. The entire delegation of 110 met for dinner at the Detroit Golf Club where special entertainment, followed by dancing, was provided. Those remaining until Saturday morning rode out to the Delray station of the Detroit Edison Co. and were served luncheon at the plant.

In England it is proposed to erect a memorial at Liverpool to form a permanent record of the heroism of the engine-room force of the "Titanic." The money will be raised by popular subscription. It is fittingly suggested that the memorial be placed somewhere on the bank of the Mersey River.

Massachusetts State N. A. S. E. Convention

The seventeenth annual convention of the Massachusetts State Association of the National Association of Stationary Engineers was held in Northampton, July 11, 12 and 13, with headquarters at the Draper House.

There were about fifty delegates in attendance and many visiting engineers. The several business sessions of the convention were held in Carnegie Hall, located close to the hotel. The main floor of the City Hall was tastefully arranged for the display of power-plant machinery and supplies under the direction of the New England Association of Commercial Engineers. The exhibit opened at noon on Thursday.

At 10 o'clock on Thursday evening the convention was entertained with a smoker given by the supplymen at Rahr's Inn. Interesting talks and vocal and instrumental music combined to make an interesting program.

At 11 o'clock Friday morning at Carnegie Hall the formal opening of the convention took place, Charles H. Hill, chairman of the local committee presiding.

William H. Feiker, Mayor of Northampton, gave the company a warm welcome to the city, and Past National President Edward H. Kearney responded on behalf of the association.

Frank E. Davis, president of the Board of Trade of Northampton, spoke upon the industries and beauties of the city. He was responded to by Claude D. Allen, president of the New England Association of Commercial Engineers.

Past National Presidents P. H. Hogan and T. N. Kelsey also made addresses. After the chairman made announcements and appointed committees, the meeting adjourned until 2:30 p.m. On Friday afternoon an automobile trip was taken through the city under the auspices of the Board of Trade, and in the evening an entertainment was given at Cook's Theater.

Saturday afternoon, headed by Charles Van de Wall and the Northampton Brass Band, the convention marched to the Driving Park to enjoy a clam bake. The baseball game between the engineers and supplymen was won by the former with a score of 10 to 5.

During the convention, James Sumner, retiring state president, was presented a handsome silver service. Frank E. Davis was given a tourist's hand bag and outfit, and Jack Armour, of POWER, received a gold signet ring.

The newly-elected state officers are J. T. Maloney, president; A. M. Day, vice-president; Ole B. Petersen, secretary; Walter H. Damon, treasurer; George W. Furbush, conductor; Arthur A. Austin, doorkeeper; Thomas H. Ray, state deputy.

The New England Association of Commercial Engineers elected officers as follows: Albert C. Ashton, president; Frank A. Morrison, vice-president; Herbert E. Stone, treasurer; Claude D. Allen, W. K. Campbell, John B. Harrington, W. C. Barnes, John D. Stiles, William Coppins, W. D. Hasley, B. L. Ames and W. H. Walker, directors.

EXHIBITORS

Autogenous Welding Co., the Roto Co., *Southern Engineer,* Patterson Lubricating Co., Lagonda Manufacturing Co., Universal Supply Co., Gardner Grate Co., Curry Brothers Oil Co., Quaker City Rubber Co., Johns-Manville Co., Burke Engineering Co., American Steam Gauge & Valve Co., Hart Packing Co., Jenkins Brothers, *National Engineer,* V. D. Anderson Co., McLeod & Henry Co., Hyland Manufacturing Co., Mason Regulator Co., Philadelphia Grease Co., the Texas Co., A. W. Chesterton Co., Durabla Manufacturing Co., Dearborn Drug & Chemical Works, Perfection Grate Co., Walter G. Ruggles Co., Monarch Valve Co., Evans Mill & Supply Co., Manning, Maxwell & Moore, Robb Engineering Co., Lunkenheimer Co., American Steam Packing Co., Ashton Valve Co., W. R. Winn, Greene, Tweed Co., Schaffer & Budenberg Manufacturing Co., Enterprise Rubber Co., Peerless Rubber Co., Holyoke Valve & Hydrant Co., George W. Knowlton Rubber Co., Keystone Lubricating Co., Adam Cooks' Sons, Economy Lubricating Co., Chicago Pneumatic Tool Co., POWER, Charles A. Claflin & Co., Strong Machine & Supply Co., Garlock Packing Co., Eagle Oil & Supply Co., Home Rubber Co., Nonotuck Silk Co., Northampton Silk Co., *New England Engineer,* Chapman Valve Co.

The city of Lawrence was chosen for the 1913 convention.

Manufacturrs Adopt Flanged Fitting Schedule

At a meeting of the Committee of Manufacturers on Standardization of Fittings and Valves, held at 30 Church St., New York City, July 10, 1912, the "Manufacturers" 1912 schedule of flanged fittings and flanges was adopted to take effect Oct. 1, 1912. There was practically no opposition among the manufacturers present to the adoption of this schedule, but one vote being recorded against it. Copies of this schedule will be printed and distributed to the manufacturers and the trade generally as soon as possible.

New list prices for brass and iron-body swing-check valves, standard and extra heavy, were adopted at this meeting, to take effect Oct. 1, 1912, copies of which will be printed and distributed to the trade as promptly as possible.

Flywheel Explosion in Brooklyn, N. Y.

At 9 a.m. Saturday, July 6, the 16-ft. by 25-in. flywheel of a 20x38-in. Watts-Campbell Corliss engine exploded in the National Sulphur Works plant, at 618 Kent Ave., Williamsburg, Brooklyn, N. Y. Contrary to daily-press reports, the boilers did not explode as the result of being hit with a piece of the wheel.

The engine is located one floor below the street and directly beneath a room in which the employees handle the sulphur. On the level with the engine room and separated from it by a 12-in. brick wall, is another work room. Fortunately, no workmen were in this room at the time of the accident, as most of the wheel went through the wall into it, but three men on the floor above, as a large piece of the wheel crashed through it, were thrown 20 ft. through a doorway into the street. They were slightly injured.

The cause of the explosion is not known, even by the engineer, but it is assumed that the governor belt lacing broke and that the pin was left in the governor, not allowing it to close the admission valves, as the engine ran away.

The wheel weighed about 17,000 lb. and every arm was broken close to the hub. The large driven pulley back of the head end of the cylinder was likewise broken and the shaft moved back 4 in. The eccentric strap and wrist plate were also broken, the crank-end dashpot plunger pulled from its cylinder, and the entire engine moved about 1 in. in a line parallel with itself.

Photographs of the wreck are unavailable, as the company desired that none be taken. Four years ago a similar accident happened, and it is understood that still another occurred seven years ago.

Court Sustains Long Acre Co.

On July 11, by a vote of three to two, the Appellate Division of the Supreme Court sustained the Public Service Commission ruling giving the Long Acre Electric Light & Power Co. authority to issue $2,000,000 of bonds after $1,000,000 of new stock has been subscribed and paid for, and an additional issue of $2,000,000 of bonds after another $1,000,000 stock issue has been subscribed and paid for.

The order also provided that the bonds were to be disposed of only at public sale, and at not less than 90 per cent. of their real value, and also that the proceeds of the stock and bonds were to be expended only after an itemized bill for expenditure had been submitted.

The case was taken before the court by the New York Edison Co. on an order to review the commission's ruling on the ground that the commission had no power to authorize the stock and bond issue, and for the further reason that since the Edison company is furnishing electricity at reasonable rates there is no occasion for a competitor to enter the field.

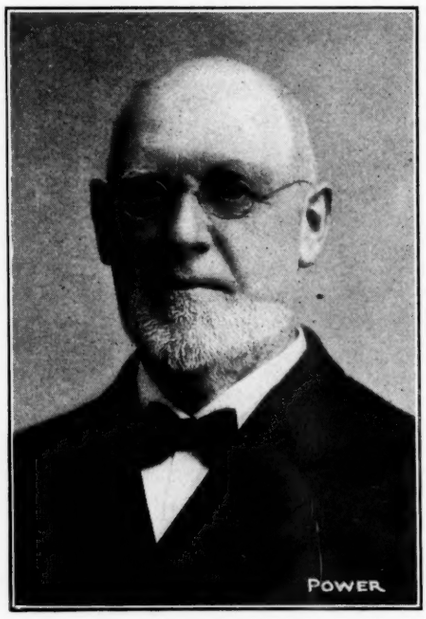
The case will now go to the Court of Appeals and if the decision of the Appellate Division is sustained, the Long Acre company will begin active business as soon as it is financed.

OBITUARY

George R. Babbitt

George Rodney Babbitt, the well known consulting mechanical engineer, died at his home, 130 Shaw Ave., Edgewood, R. I., on June 29, in his seventy-first year.

Mr. Babbitt was born in Berkley, Mass., and was educated in the local public schools and at the Hermitage Home



George R. Babbitt

School, Fall River. In 1860, he sailed around the Horn to San Francisco in the "Sierra Nevada" and later was second mate in the "Maria Theresa," one of the fleet of New Bedford whalers sunk off the southern ports in the early Civil War.

In April, 1862, Mr. Babbitt entered the employ of the Burnside Rifle Works, Providence, R. I., and became a subcontractor. Early in 1866, he was employed by William A. Harris, the Harris-Corliss steam-engine builder, filling the positions of machinist, foreman and superintendent. Mr. Babbitt was a natural mechanic, never having served an apprenticeship. While in this engine shop he invented and patented several improvements, one of which was a piston packing for which he received a medal at the Cincinnati Industrial Exposition, in 1874.

In 1888, he declined the superintendency of the heavy-ordnance department of the Government, at Washington, D. C. He retired from business on Mar. 31, 1891, having completed a quarter of a century in building and designing engines. Mr. Babbitt invented a releasing gear for the Corliss engine, also an extended piston. In April, 1892, he bought an interest in the American Oil Co., Providence, R. I., which connection he retained until his death.

Mr. Babbitt was a member of the American Society of Mechanical Engineers and the National Association of Stationary Engineers, and was commodore of the Edgewood Yacht Club.

A. W. Harris

On June 30, A. W. Harris, president and general manager of the A. W. Harris Oil Co., Providence, R. I., died at his home in that city after a brief illness His widow and a daughter survive him.

In the early eighties Mr. Harris began the manufacture of high-grade steam engine and cylinder oil, and was among the leaders in that line. When the automobile industry first attained prominence, more than a decade ago, he began to supply high-grade lubricants for gasoline motors.

Mr. Harris had a wide reputation in business for integrity, and a large social acquaintance. He was descended from a long line of Americans who have done things in the mechanical world, among them his uncle, William A. Harris, who built the Harris Corliss engine.

PERSONAL

Albert C. Ashton, treasurer of the Ashton Valve Co., Cambridge, Mass., has been nominated by the New England Association of Commercial Engineers for president. Mr. Ashton is a member of the American Society of Mechanical Engineers, Engineers Blue Room Club, Railway and Supply Manufacturers' Association, and several boards of trade.

Byron T. Gifford, formerly with the Central Station Engineering Co., Chicago, Ill., is manager of the recently inaugurated general engineering department of the American District Steam Co., North Tonawanda, N. Y. James A. Bendure, of the Economy Light, Fuel & Power Co., Lockport, N. Y.; A. E. Duram and C. A. Gillham, of the Central Station Engineering Co., Chicago, have resigned and become associated with the American District Steam Co. in its contracting department. The company's Chicago offices have been moved from the Monadnock Block to the ninth floor of the First National Bank Building.